

Using Intraseasonal Indices in Daily Forecast Preparation

Miles Schumacher – NWS Forecast Office Des Moines, IA

Why would you want to look at intraseasonal indices? Intraseasonal indices can suggest insight into the week 1-3 timescale and reflect local or regional state of the atmosphere. At first it may seem that using intraseasonal atmospheric indices is something that only researchers use. The idea of using intraseasonal indices stems from the concept of presented by Len Snellman in the COMET module “Forecast Process”. In a nutshell, the idea of the Forecast Funnel is presented whereby one begins the forecast process by looking at the large scale, then looking at the smaller scale.

The idea of using intraseasonal indices is analogous to the use of teleconnections of 500 mb height patterns in forecasting. “Tele” is from the Greek meaning distance; hence teleconnection simply means distance connection. Simply put, “if this happens here, that will happen there” type of thinking. There are several intraseasonal patterns that we can use as forecasters to help give insights into weather behavior. Often, knowledge of the cause of effect brought on by various intraseasonal patterns will tip the forecaster off to the potential of an erroneous model run.

It is important to realize that one can not simply look at one of the indices and assume that everything will follow just what the teleconnections suggest. Unfortunately, nature is not that simple. Many times one or more of the patterns will interact with each other. One may be clearly dominant, but this is not always the case.

It is important to realize that there are interactions between various intraseasonal patterns and therefore you must look at several. The strength of a particular pattern is important as one may tend to counter another, or enhance the other, depending on which phase each one is in.

There are several teleconnection patterns that are important to follow when forecasting trends in U.S. weather. The most important are, NAO, (North Atlantic Oscillation), WP (West Pacific), EP, (East Pacific), NP, (North Pacific), PNA (Pacific North American), and to a lesser degree, SCAND (Scandinavia), EATL/WRUS, (East Atlantic/West Russian), and Polar-Eurasia patterns. In addition to teleconnection patterns, perhaps the most significant intraseasonal factor is the MJO, (Madden-Julian Oscillation). The Madden-Julian Oscillation is the development of periodic tropical convection, occurring on the intraseasonal timescale (in this case every 30-60 days), which in turn interacts with the mid-latitude westerlies. It is a naturally occurring component of the coupled ocean-atmosphere system.

I want to start out with a brief review of the influence of MJO on weather patterns around the globe. The MetEd site has a good module on the life cycle of the MJO and can be

found at: <http://meted.ucar.edu/climate/mjo/index.htm> , other information can be found in the DLCC course and on the Climate Prediction Center website.

A brief discussion about MJO will be included here. MJO is generally broken up into index 1 through 10 during its life cycle. The index is based on the location of the MJO convection, see Fig 1. The MJO is broken down into 10 index numbers, with index 1 at 80 E. An eastward progression of ~20 degrees corresponds to an increase of one index number. Index numbers 9, 10, and 1 tend to be cold for the central U.S. Index numbers 3-8 tend to be warm. Index numbers 4 and 5 are typically a wet period.

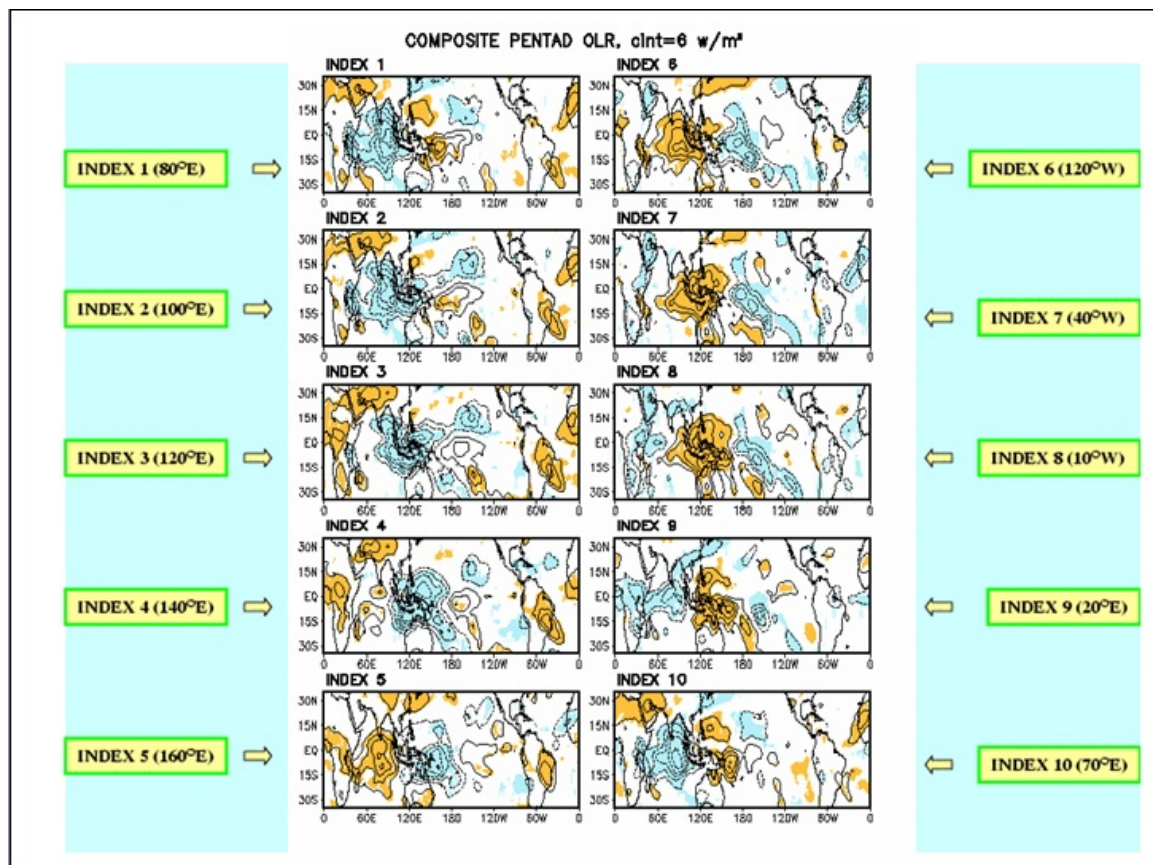


Fig 1. The figure shows the 10 indices of MJO based on the location of the strongest MJO convection (blue areas on the chart) in the tropics..

Below are three charts showing the temperature (Fig2), precipitation (Fig 3), sea level pressure (Fig 4), and global 500 mb height (Fig 5) affects of the MJO phase across the U.S. and Pacific areas for each of the corresponding index numbers.

COMPOSITE PENTAD U.S. TEMPERATURE, $\Delta T = 0.5^\circ\text{C}$

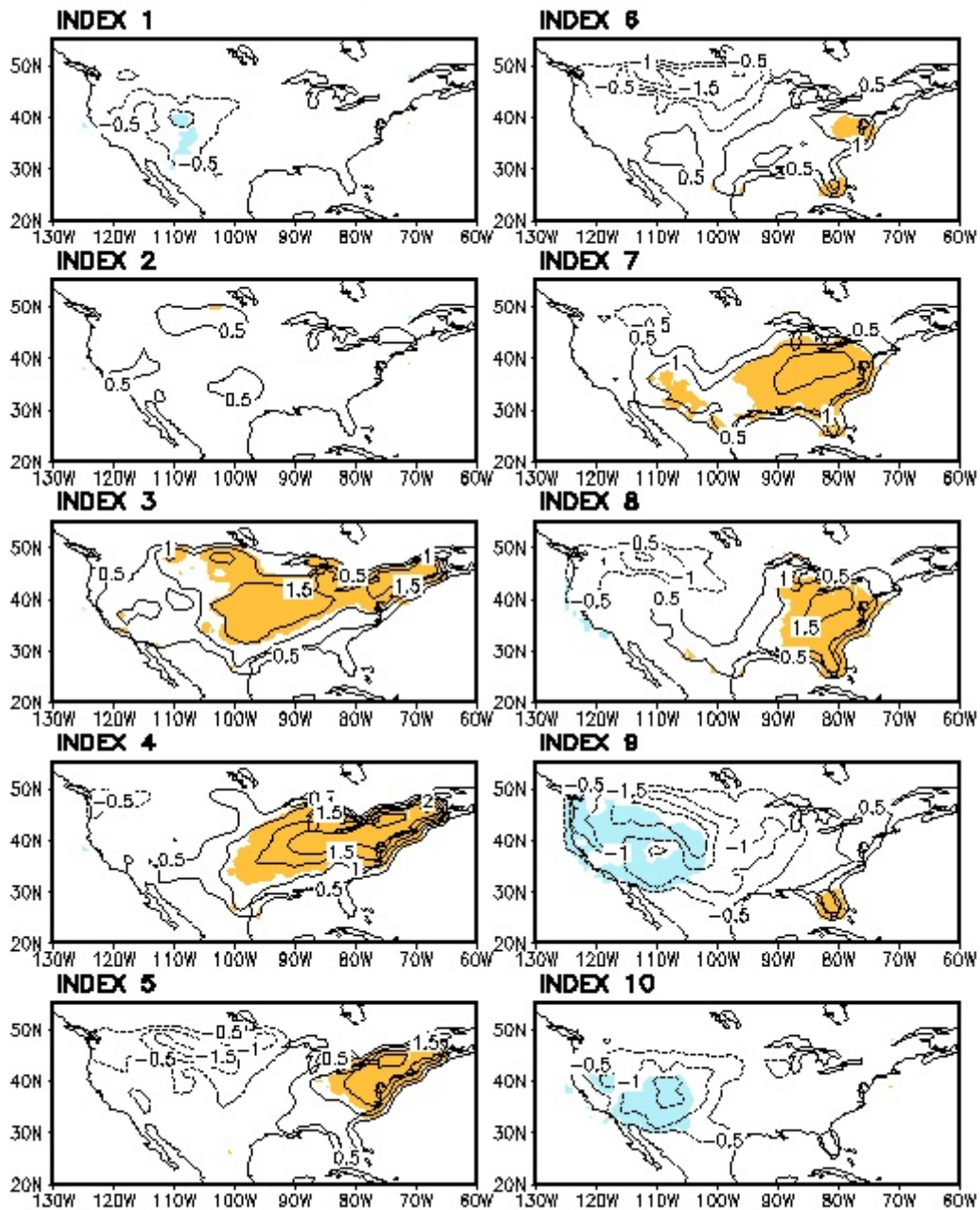


Fig 2. Showing typical temperature departures (0.5 degrees C) in the U.S. for corresponding MJO index numbers.

COMPOSITE PRECIPITATION, cInt=0.3 mm/day

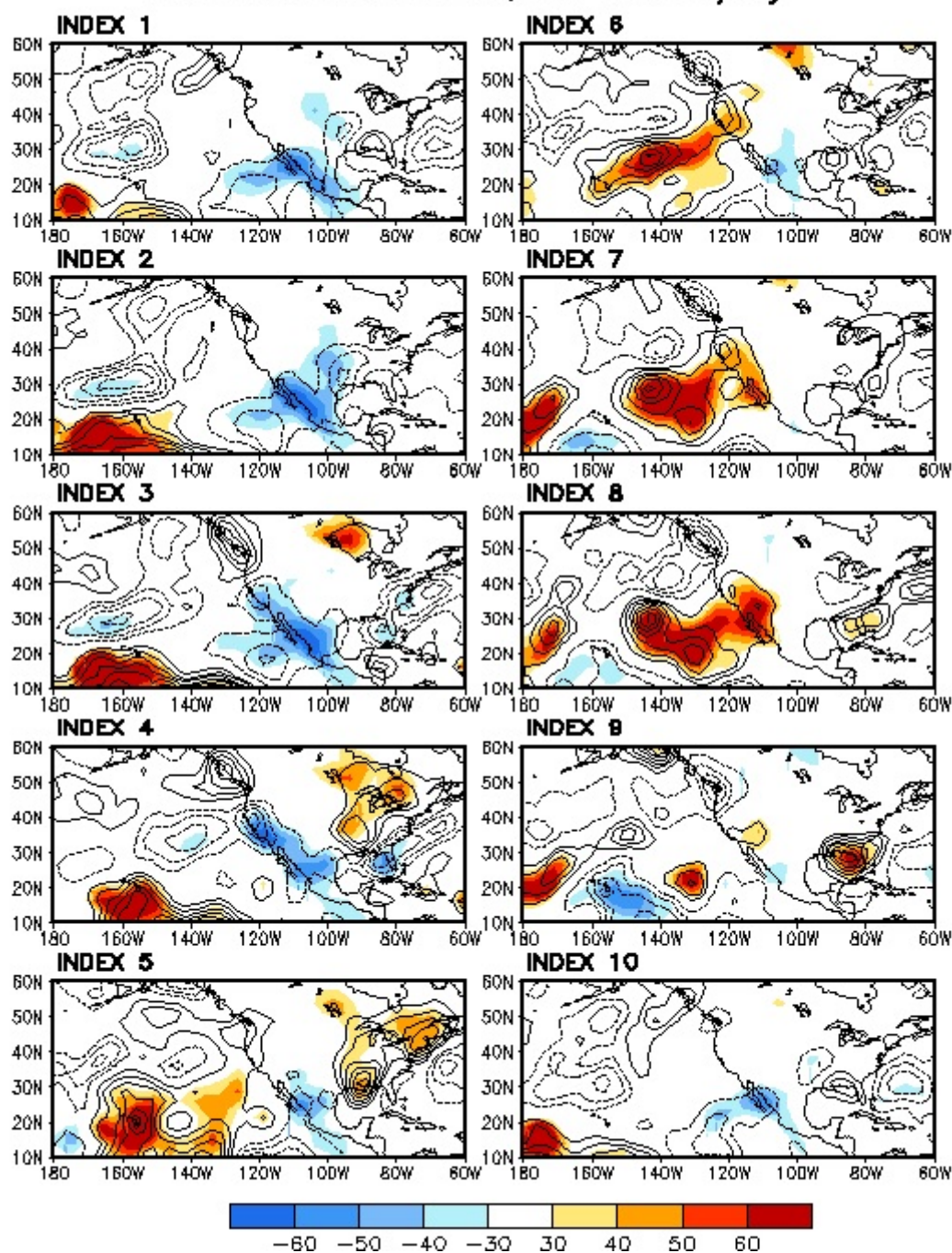


Fig 3. Showing typical precipitation departures (0.3 mm/day) in the U.S. and east Pacific for corresponding MJO index numbers.

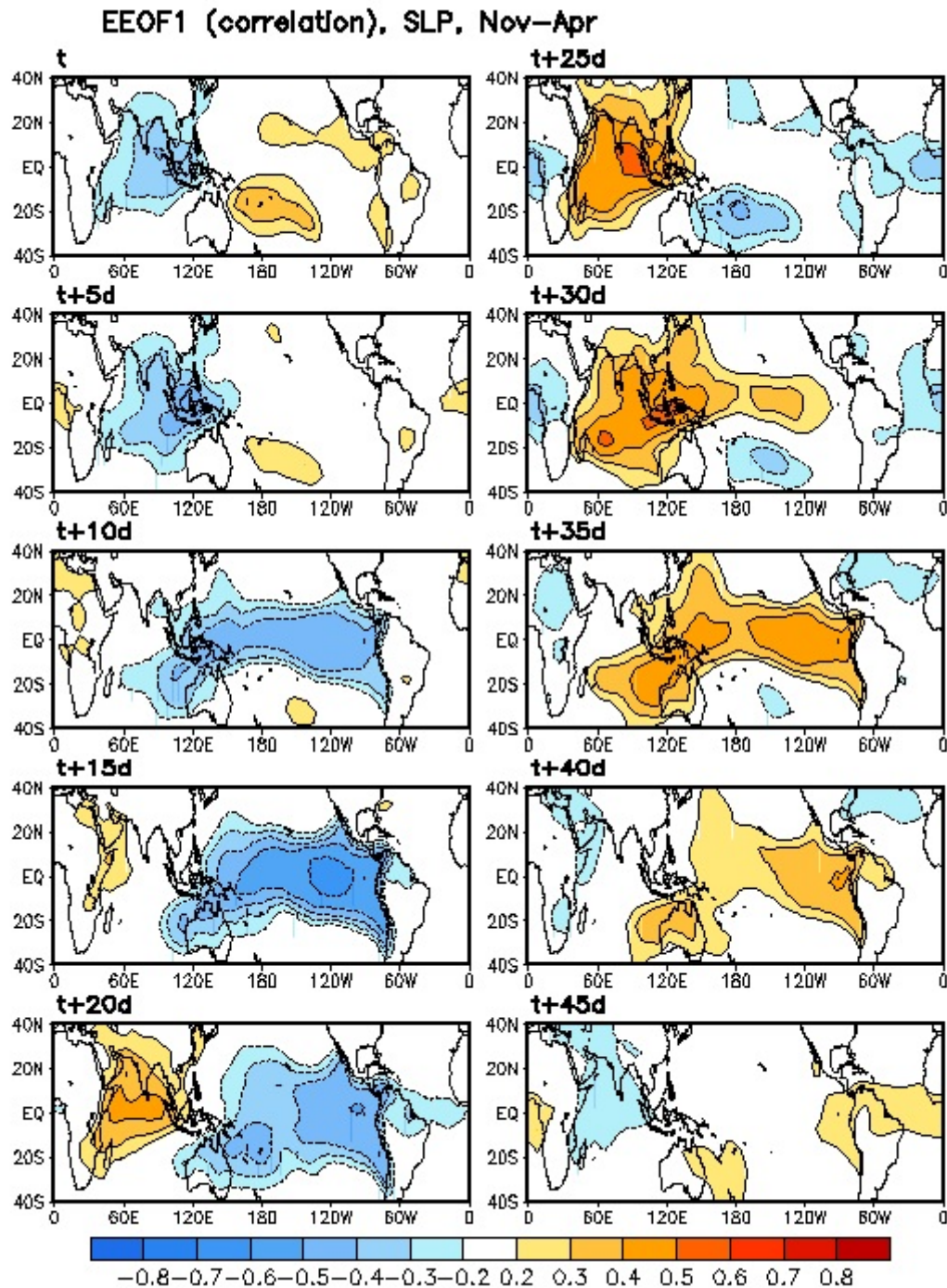


Fig 4. Showing typical correlation of sea level pressure across the Pacific and west Atlantic from 40 degrees S. to 40 degrees N. for corresponding MJO index numbers.

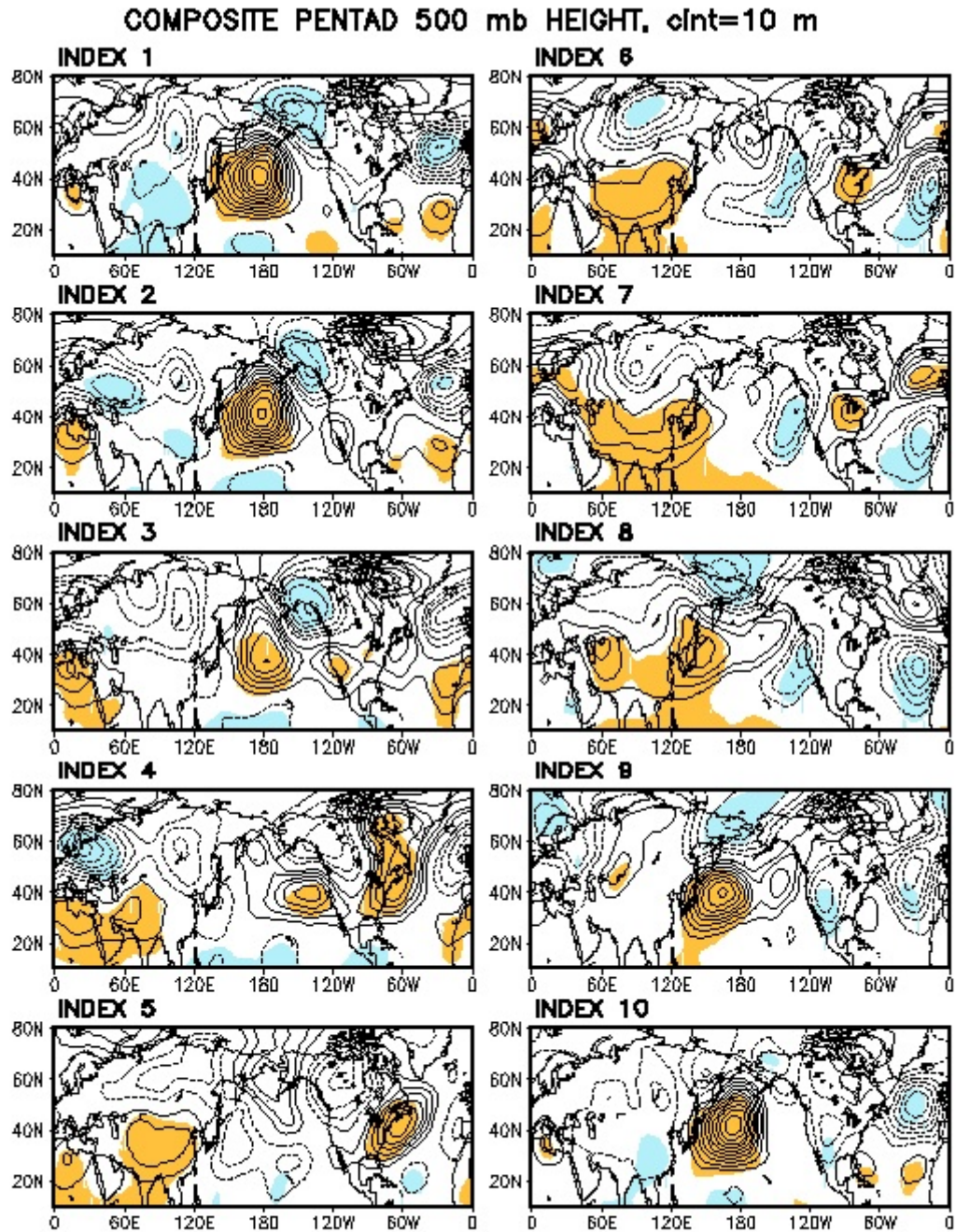


Fig 5. Showing typical composite of 500 mb height departures (10 m) for the northern hemisphere from 0 degrees latitude to 80 degrees N. latitude for corresponding MJO index numbers.

The current status of MJO can be obtained from the CPC website. The maps produced are Hovmoller diagrams of convection versus non convective areas. The charts can be used directly to compare against the index numbers shown in figure 1. An example chart is shown below in figure6 .

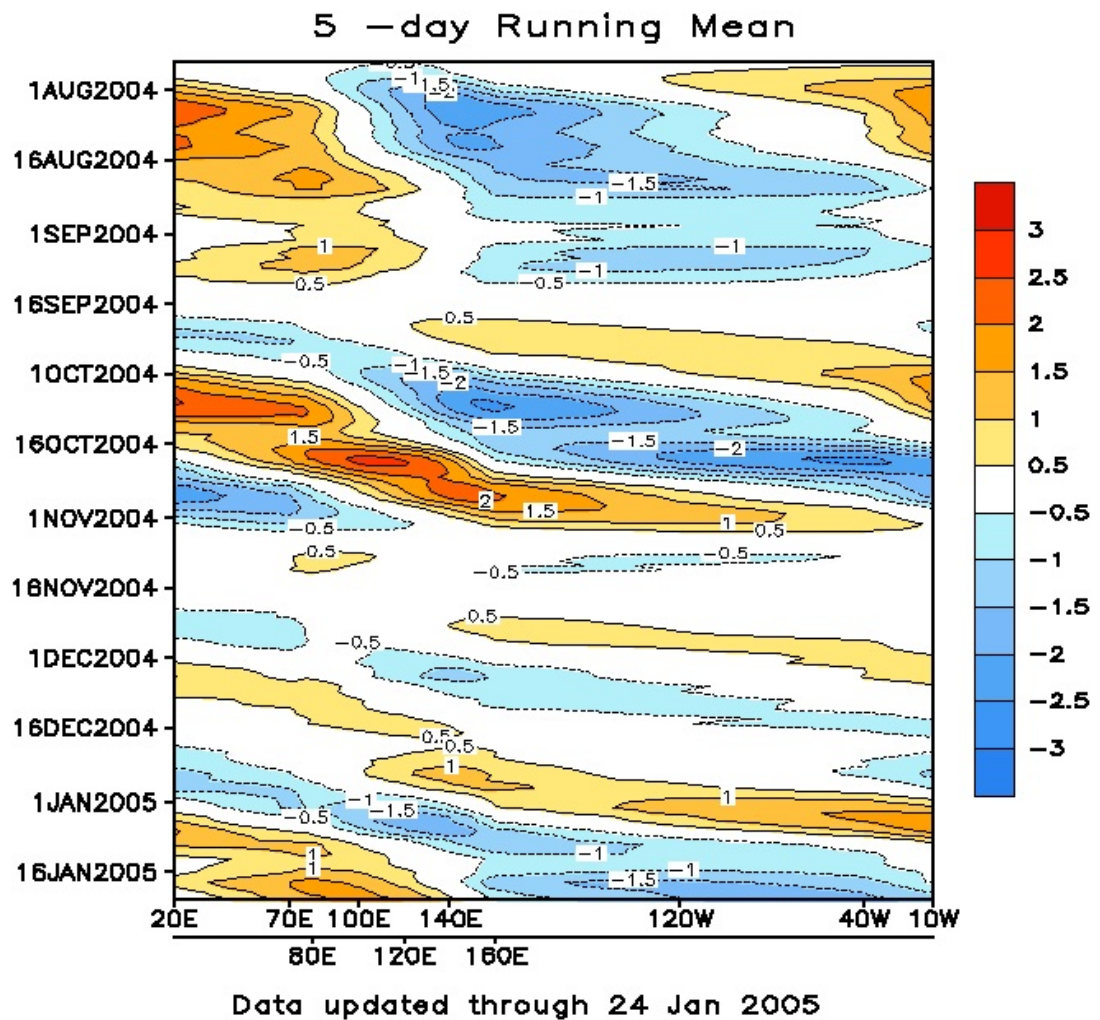


Fig 6. Recent display showing approximately 6 month progression of the MJO in a Hovmoller style display.

In addition, forecasts are available on a daily basis of the progression of the MJO. Two models produce these forecasts. The EWP runs daily and produces a 40 day forecast of Velocity Potential (CHI) at 200 hPa. Figure 7 below shows an example of this output. Similar output is produced daily from the GFS model out to 15 days, and is shown in Figure 8.

**CHI 200 hPa 40-DAY forecast (00z25jan2005–06mar2005)
(based on EWP zonal harmonics)**

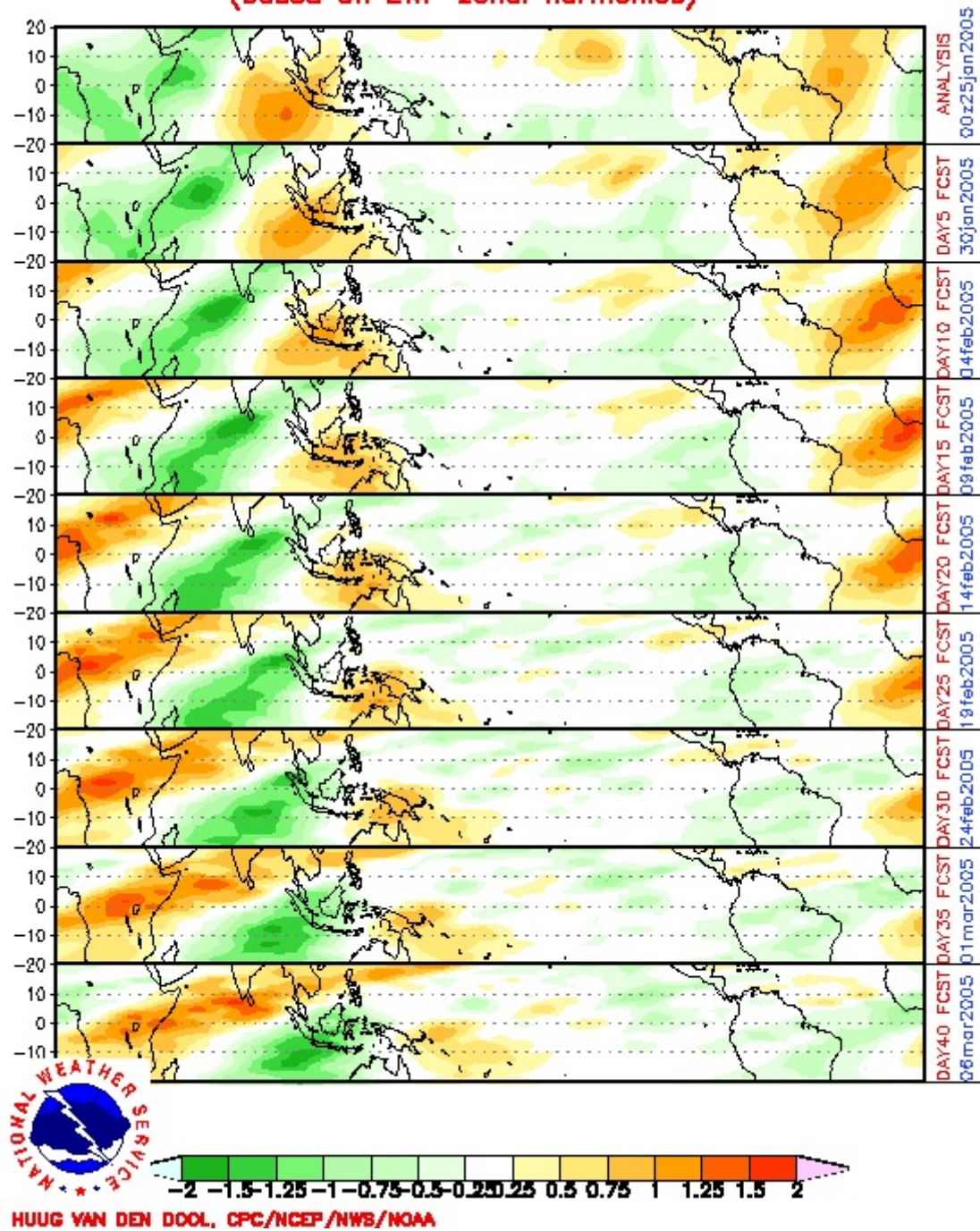
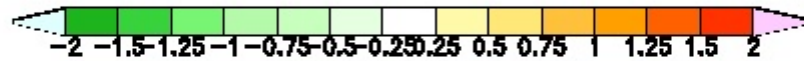
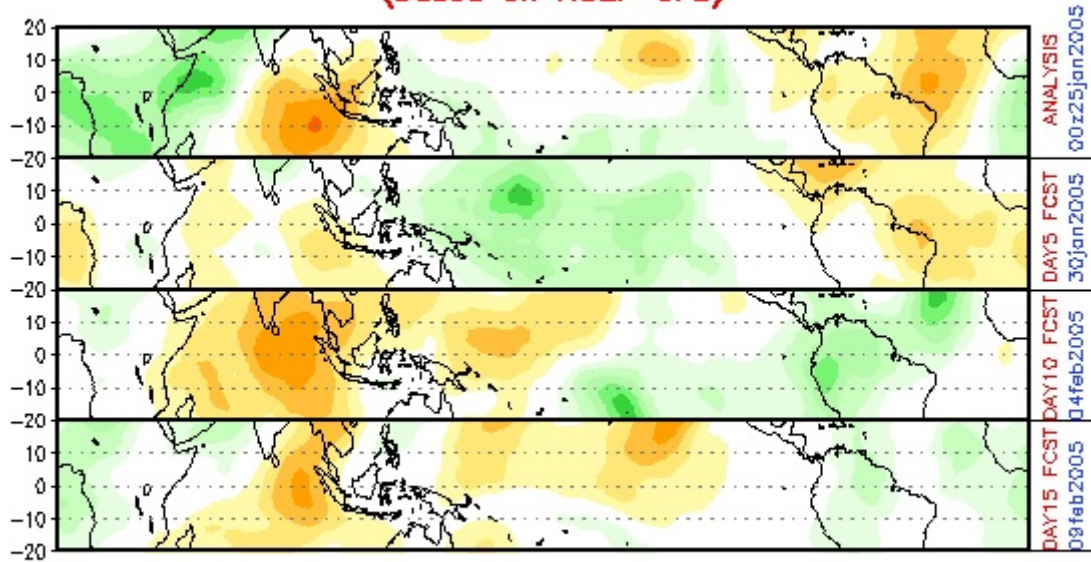


Fig 7. Example of output of 200 hPa Velocity Potential from EWP showing the 40 day forecast.

**CHI 200 hPa 15-DAY forecast (00z25jan2005–09feb2005)
(based on NCEP GFS)**

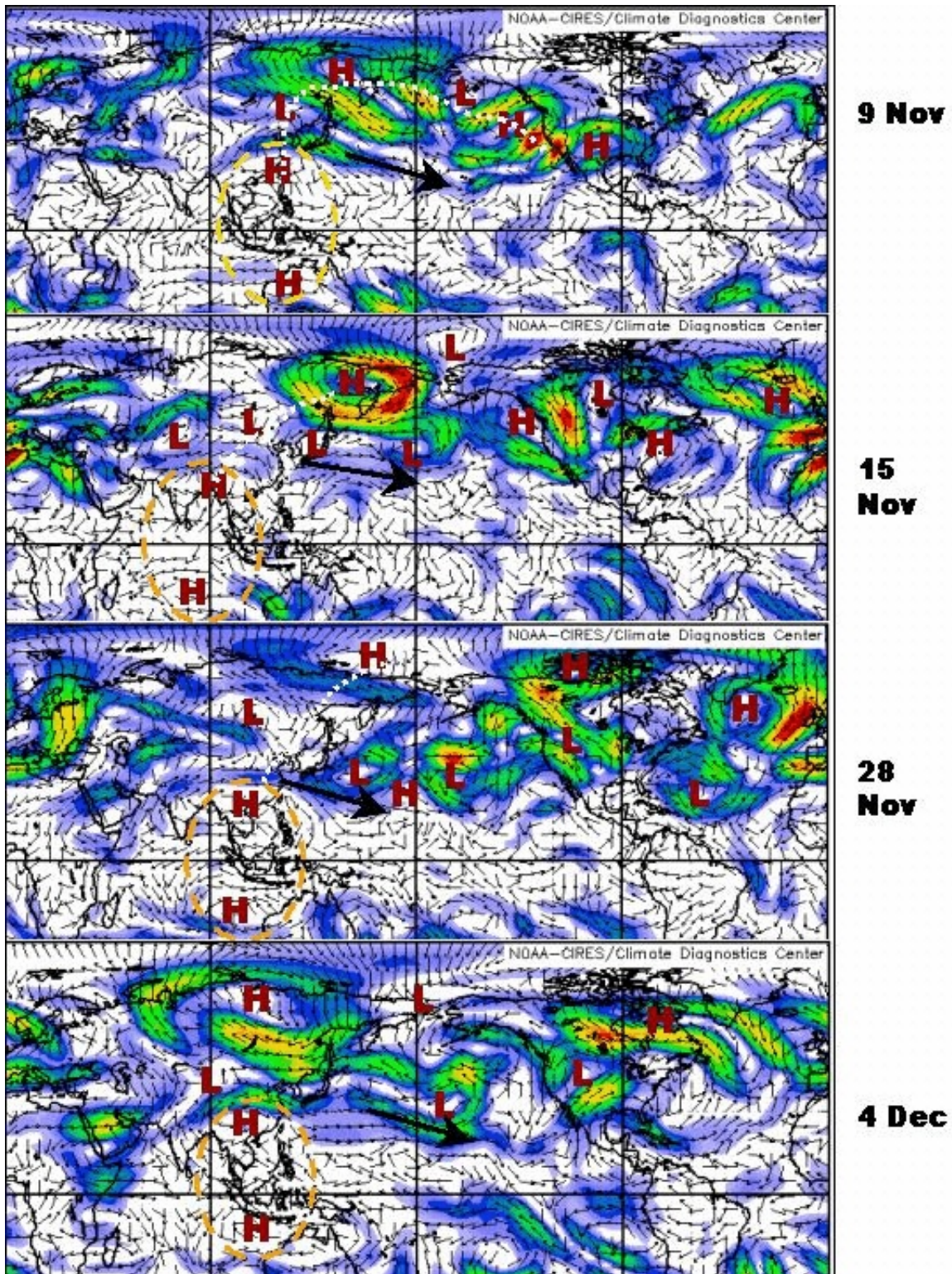


HUUG VAN DEN DOOL, CPC/NCEP/NWS/NOAA

Fig 8. Example of output of 200 hPa Velocity Potential from GFS showing the 15 day forecast.

The MJO appears to have the strongest influence on northern hemispheric weather patterns, however several other teleconnection patterns need to be considered. The information below was obtained from the CPC website. Forecasts for several of these patterns are available from the CPC website out to 15 days as well. Each of the maps below show corresponding 500 mb height departures for the positive phase of the teleconnection for the northern hemisphere. For negative phase, the changes at 500 mb are the opposite.

The MJO had a definite affect on the jet stream pattern. An example of effects on the jet stream is presented below. Though a good example, this sequence of events was somewhat unusual in that a much stronger than normal Pacific wave train developed during this period.



The sequence above is a selection of daily mean maps of 250mb vector wind anomaly and are used to summarize the observed circulation anomalies, including the ridges and troughs that influence local weather. The map here shows the red H's (L's) are the anticyclonic (cyclonic) circulation anomalies, the dashed orange ovals indicate the twin

anticyclones forced by the persistent Indonesian convection (not shown), and the black arrows give a sense for the wind directions.

The sequence begins 9 November 2005 when Rossby wave dispersion (RWD) occurred across the Pacific Rim (white dashed curved line), linked to a convective flareup over the west Pacific. The orange oval highlights the location of twin anticyclones linked to tropical convection anomalies. As part of the RWD, a blocking anticyclone developed over northeast Asia, the first in a series of such events. At least 3 more RWDs linked to the Indonesian tropical convection occurred afterwards (15 Nov, 28 Nov and 4 Dec) as is shown. During this period (9 November-4 December), not only did the northeast Asian blocking anticyclone persist, but it expanded and contributed to large anticyclonic anomalies across most of the Arctic. This produced negative projections onto both the AO and NAO. The growing easterly anomalies in high latitudes (55-90N), suggest a southward momentum flux into mid-latitudes.

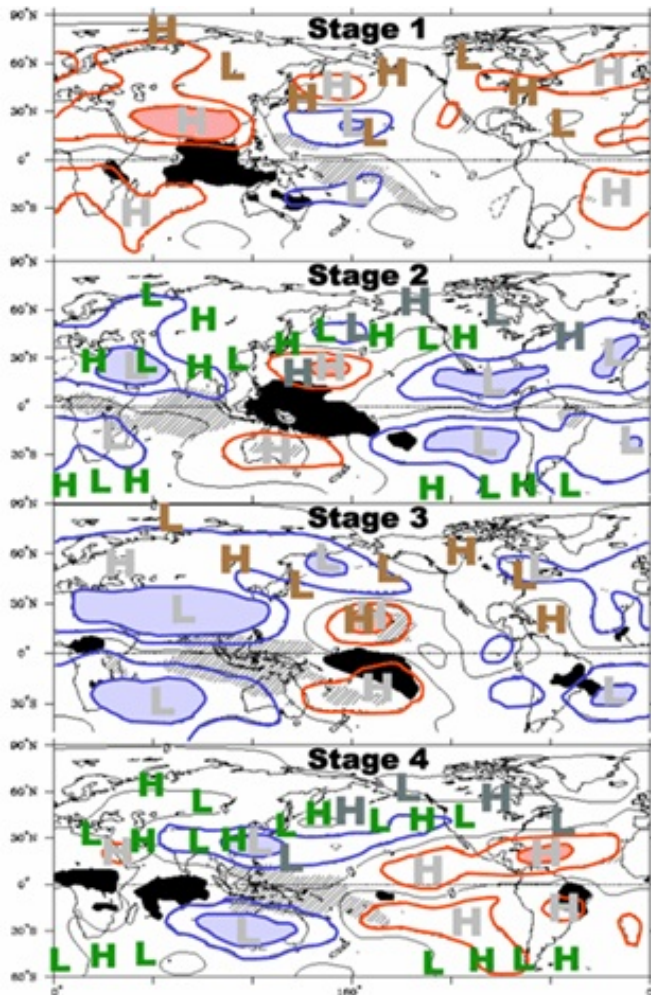
This sequence is from a paper by Klaus Weickmann and Ed and Berry: A Synoptic-dynamic model of Subseasonal Atmospheric Variability (submitted for publication in Monthly Weather Review 10/05). Another concept from the paper I would like to introduce is the Global Synoptic Dynamic Model (GSDM). An introduction is shown below as an introduction to the Global Synoptic Dynamic Model. It is only an introduction and not meant to get into the theoretical details of what is taking place, which are beyond the scope of this module. Rather, it is meant to show a little of how the entire climate system of the Earth is linked together and how intraseasonal variability also affects weather on the shorter timescale of one to two weeks. Research is ongoing, but it is important to point out that the GSDM takes into account more than just the response from MJO. It is a framework derived from lagged linear regression onto multiple time scales and is designed to organize the evolution of global scale circulation into a repeatable sequence of events. Without getting into deep detail, in addition to MJO, consideration is made for teleconnections linked to mountain and frictional torque index cycles, submonthly variations on the 10-30 day timescale and baroclinic wave packets. The underpinnings of the GSDM are Atmospheric Angular Momentum. AAM variation tends to run in a 20 to 25 day cycle.

Four of the major components, all of which are on different time scales, are Rossby Wave Dispersion, Energy packets, MJO, and Mountain Torque. When these work together, the synoptics are maximized.

From these maps, one can see how the MJO convection indeed affects not only the mid latitudes, but the polar latitudes as well. There is much more to be considered, however that is well beyond the scope of this paper.

With that said, I'd like to briefly introduce the GSDM. The four stages of the global synoptic-dynamic model (GSDM) of subseasonal variability for the northern hemisphere cold season (November-March). The red (blue) isopleths and shading depict subtropical anticyclonic (cyclonic) 200mb streamfunction anomalies (inter-hemispheric sign reversal understood) that accompany MJO tropical convection anomalies as they move east. The

black (hatched) shading shows the areas of enhanced (suppressed) convection with the MJO. The “Hs” and “Ls” are used to show the associated anomalous anticyclonic (or “high pressure”) and cyclonic (or “low pressure”) gyres. The lighter gray “Hs” and “Ls” are for the MJO while the heavier gray ones illustrate a west Pacific wavetrain linked to the MJO at Stage 2. The brown “Hs” and “Ls” depict teleconnection patterns associated with the frictional torque, and the green ones show synoptic-scale wavetrains. See forthcoming text, “A synoptic-dynamic model of subseasonal atmospheric variability” (Weickmann and Berry) in MWR, for additional details. Below is the presentation of the GSDM:



A brief listing of characteristics is given for each of the four stages.

In the next 4 slides I will briefly summarize some of the typical characteristics of each of the four stages:

Taking a closer look at each stage, we see some typical effects during each one. For example, **GSDM 1** is often associated with a split jet over the Pacific and high impact weather in the central U.S.

- MJO convection around 110E with enhanced (suppressed) tropical convective forcing across the eastern (western) hemisphere;
- Amplified (tropical/subtropical) seasonal base state;
- Low AAM / strengthened subtropical momentum sink;
- $PNA < 0$ forced by M- F index cycle ($M < 0$, $F > 0$ sequence);
- Contracted east Asian and North American jets, displaced poleward/split flows over the oceans;
- The MJO and M- F index cycle give large positive frictional torques;
- La Nina like base state with Pacific Ocean anticyclonic wave breaking;
- Wave energy dispersion favors high impact weather across the USA Plains.

For **GSDM 2**. Typically one finds a fast moving Pacific wave train. SDM 2 can lead to cold temperatures in the central U.S., especially during the transition from SDM 1 to SDM 2.

- MJO convection around 150E
- Eastward shifted seasonal base state;
- $d(AAM)/dt > 0$ / momentum sink shifting poleward;
- The MJO and fast time scale component give large positive mountain torques;
- Western Pacific to North American Rossby wavetrain/strong ridge from USA west coast into Alaska;
- Asian-Pacific wavetrain favors east Pacific cyclonic wave break for transition to Stage 3;
- Much below normal temperatures possible across central and eastern USA.

During **GSDM 3** one typically sees high impact weather along the west coast. The jet stream often splits over the continental areas. Temperatures tend to be mild over the central and eastern U.S.

- MJO convection around date line with enhanced (suppressed) tropical convective signal across the western (eastern) hemisphere;
- Deamplified seasonal base state;
- High AAM / weakened subtropical momentum sink;
- $PNA > 0$ forced by mountain torque > 0 , friction torque < 0 sequence;
- Extended east Asian and North American jets, displaced equatorward /split flows cross the continents;
- The MJO and M- F index cycle give large negative frictional torques;
- El Nino like base state with east Pacific Ocean cyclonic wave breaking;
- High impact weather event possible along USA west coast.

During **GSDM 4** the westerlies tend to weaken. Temperatures tend to be mild over the central and eastern U.S.

- MJO convective signal across the western hemisphere, locations at $\sim 160W$, $60W$ and $60E$
- Westward shifted seasonal base state;
- $d(AAM)/dt < 0$ / weakened momentum sink shifting poleward;
- MJO and fast component give large negative mountain torque;

- Strong subtropical jets, with subtropical westerlies weakening;
- Asian-Pacific wavetrain favors anticyclonic wave break across east Pacific Ocean for transition to Stage 1;
- Heavy precipitation event possible across southwestern USA.

Next I would like to show how we can use the daily MJO charts. In the graphic below, pictured is the 200 mb CHI. Across the top is the MJO index number. Across the Bottom are the SDM phase that corresponds to the MJO index number. The vertical line represents the core of the MJO convection.

convection at index number “x” doesn’t automatically mean that you can assume GSDM “y”. One would need to look further into it, but it would give you some starting point. You may also notice how the convection tends to become weaker or more broken up as it progresses east. SST’s need to be on the order of 29 C. to support deep tropical convection. SST’s tend to be higher in the eastern Hemisphere and is the reason for the apparent weakening of convection.

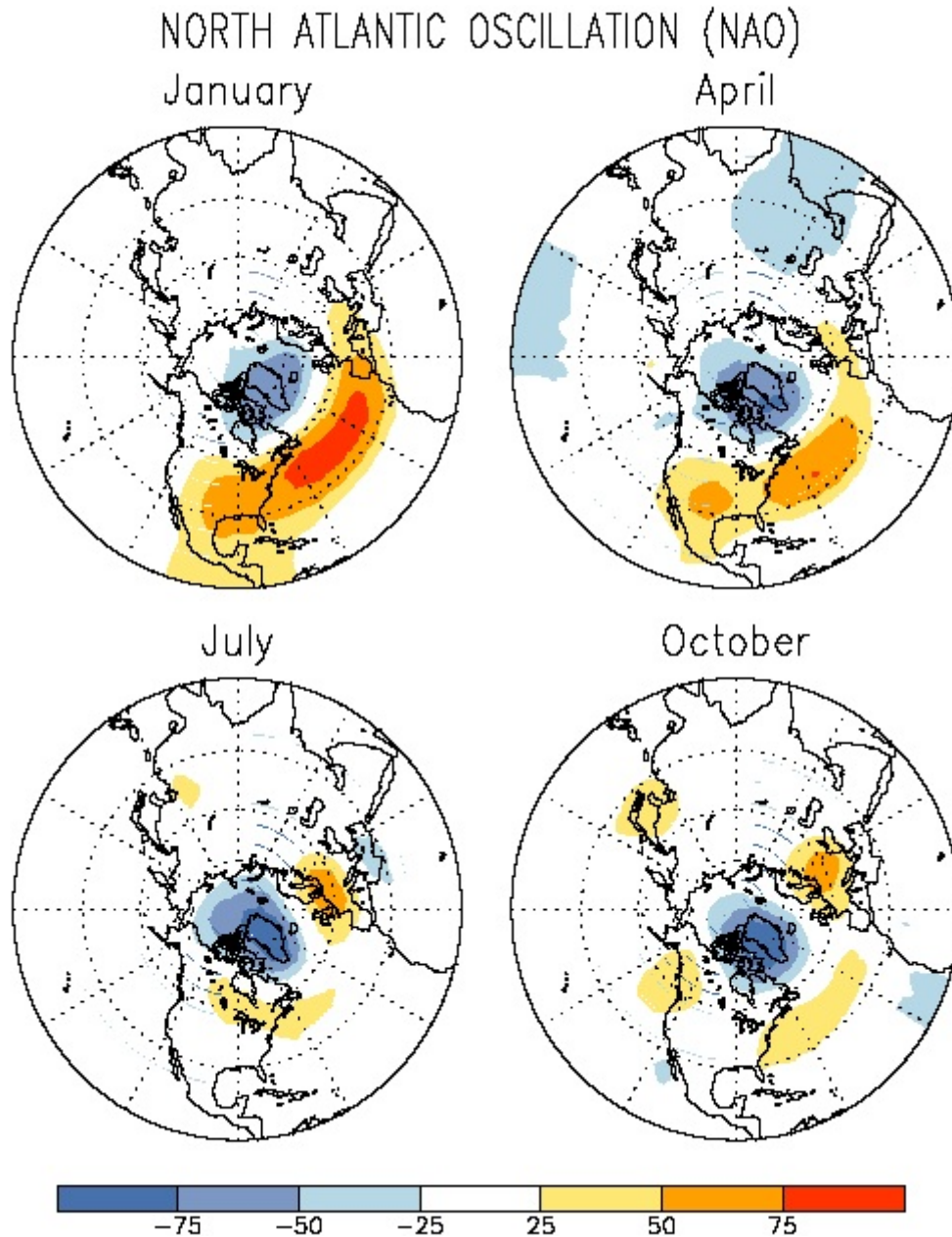
Moving on to teleconnections patterns I will start below with a chart, table 1, showing the times of the year that each pattern has the most significant affect on North America. The chart shows the ranked importance of each teleconnection pattern. For the purposes of this paper, I chose to use only the top three in rank. From the table it is clear to see that the strongest influence on North American weather on an annual basis is the NAO pattern. Other patterns are important during various times of the year. The PNA pattern is very significant during the cool season for example, while the East Pacific and North Pacific patterns are most important during the warm season.

Table 1
Calendar months when specific teleconnection patterns are important

PATTERN	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
NAO	2	2	3	1	1	2	3	2	2	5	1	1
EA	6	6	7	6	10	---	---	---	---	8	7	5
EA-JET	---	---	---	---	6	9	7	3	7	---	---	---
WP	4	3	4	3	4	4	6	7	8	10	4	6
EP	9	10	9	10	8	3	1	1	---	---	6	9
NP	---	---	---	2	2	1	2	6	---	---	---	---
PNA	3	1	2	5	5	10	---	---	6	6	5	2
EATL/ WRUS	7	8	10	7	9	7	---	---	---	7	3	4
SCAND	5	9	8	8	3	5	---	---	10	1	2	3
POLAR- EURASIA	1	4	1	---	---	---	---	---	---	---	---	---
TNH	8	7	---	---	---	---	---	---	---	---	---	8
PT	---	---	---	---	---	8	4	4	4	---	---	---
ASIAN SUMMER	---	---	---	---	---	---	5	5	5	---	---	---

Tabulated values indicate the mode number of the pattern for that calendar month (i.e., a 1 indicates that the pattern appears as the leading rotated mode during the month, etc...). No value is plotted when a pattern does not appear as a leading rotated mode in a given calendar month.

North Atlantic Oscillation – NAO



One of the most prominent teleconnection patterns in all seasons is the North Atlantic Oscillation (NAO). The NAO is documented by Barnston and Livezey (1987), and combines parts of the East-Atlantic and West Atlantic patterns originally identified by Wallace and Gutzler (1981) for the winter season. The NAO exhibits little variation in its climatological mean structure from month-to-month, and consists of a north-south dipole of anomalies, with one center located over Greenland and the other center of opposite sign spanning the central latitudes of the North Atlantic between 35°N and 40°N. The positive phase of the NAO reflects below-normal heights and pressure across the high latitudes of the North

Atlantic and above-normal heights and pressure over the central North Atlantic, the eastern United States and western Europe. The negative phase reflects an opposite pattern of height and pressure anomalies over these regions. Both phases of the NAO are associated with basin-wide changes in the intensity and location of the North Atlantic jet stream and storm track, and in large-scale modulations of the normal patterns of zonal and meridional heat and moisture transport (Hurrell 1995), which in turn results in changes in temperature and precipitation patterns often extending from eastern North America to western and central Europe (Walker and Bliss 1932, van Loon and Rogers 1978, Rogers and van Loon 1979).

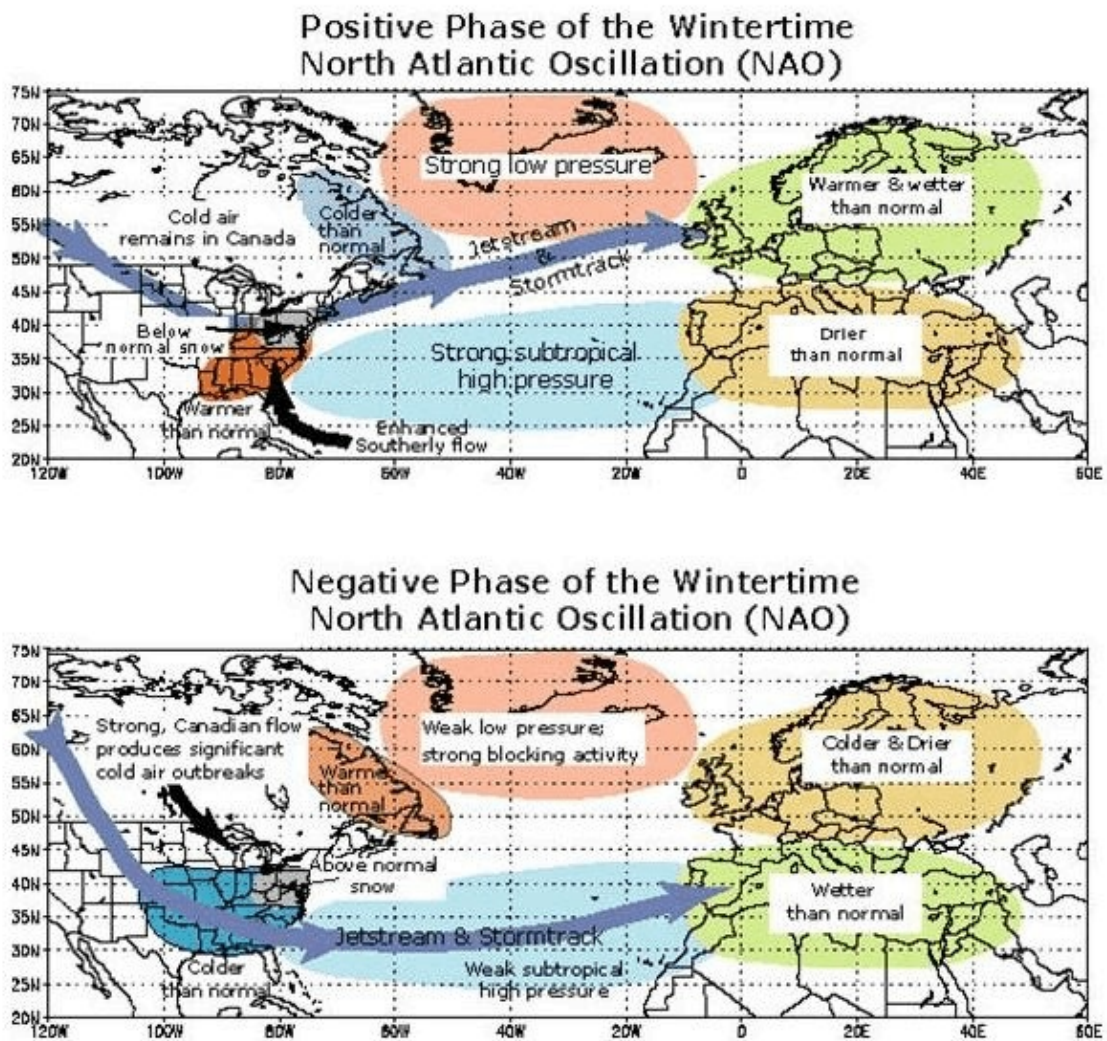
Strong positive phases of the NAO tend to be associated with above-normal temperatures in the eastern United States and across northern Europe and below-normal temperatures in Greenland and oftentimes across southern Europe and the Middle East. They are also associated with above-normal precipitation over northern Europe and Scandinavia and below-normal precipitation over southern and central Europe. Opposite patterns of temperature and precipitation anomalies are typically observed during strong negative phases of the NAO. During particularly prolonged periods dominated by one particular phase of the NAO, abnormal height and temperature patterns are also often seen extending well into central Russia and north-central Siberia.

The NAO exhibits considerable interseasonal and interannual variability, and prolonged periods (several months) of both positive and negative phases of the pattern are common. Additionally, the wintertime NAO exhibits significant interannual and interdecadal variability (Hurrell 1995). For example, the negative phase of the NAO dominated the circulation from the mid-1950's through the 1978/79 winter. During this approximately 24-year interval, there were four prominent periods of at least three years each in which the negative phase was dominant and the positive phase was notably absent. In fact, during the entire period the positive phase was observed in the seasonal mean only three times, and it never appeared in two consecutive years.

An abrupt transition to recurring positive phases of the NAO then occurred during the 1979/80 winter, with the atmosphere remaining locked into this mode through the 1994/95 winter season. During this 15-year interval, a substantial negative phase of the pattern appeared only twice, in the winters of 1984/85 and 1985/86. However, November 1995 - February 1996 (NDJF 95/96) was characterized by a return to the strong negative phase of the NAO. Halpert and Bell (1997; their section 3.3) recently documented the conditions accompanying this transition to the negative phase of the NAO. The 1996/97 winter season has exhibited a more variable nature to the NAO, with negative phases of the pattern occurring in December 1996 and January 1997, and positive phases occurring in February and March 1997.

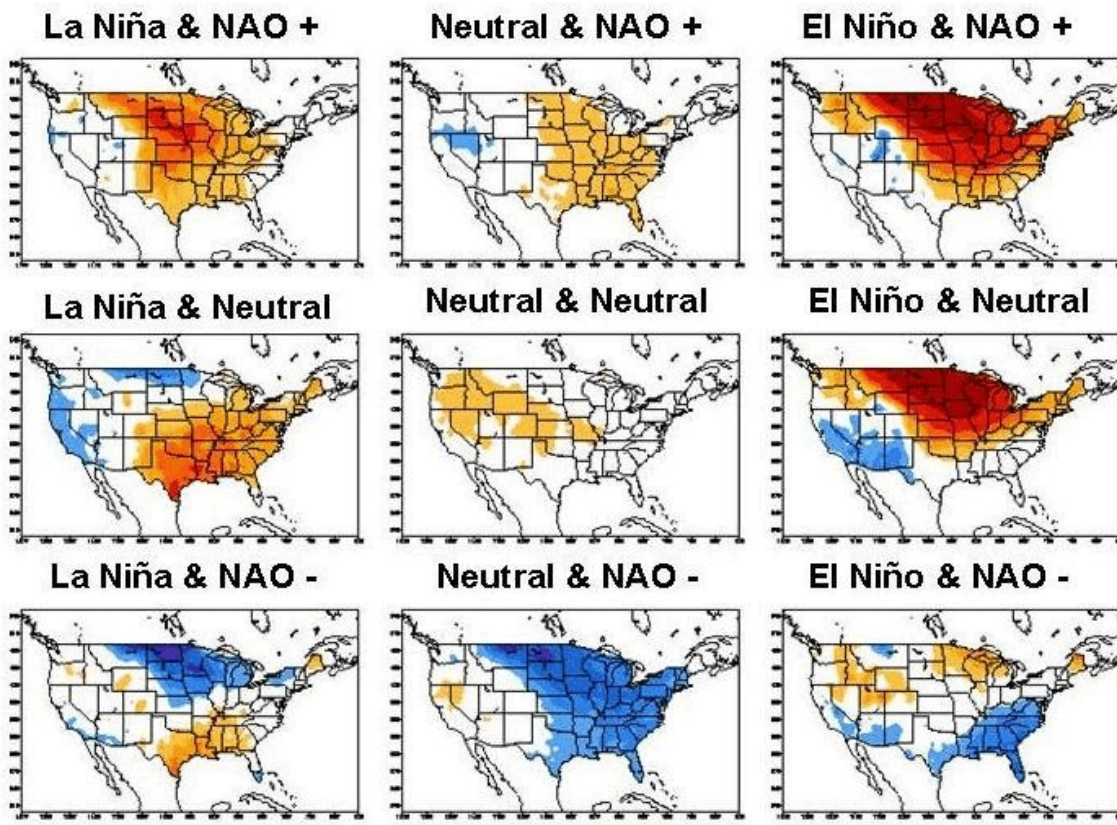
A representation of typical weather patterns associated the positive and negative phase of NAO. In the positive phase of NAO, cold air remains to the north of the CONUS in

Canada. During the negative phase of NAO, cold air sinks south into the northeast one third to one half of the CONUS. (see graphic below).



A set of correlation maps is presented here to show the effects of ENSO and NAO combined. Labels on the chart should be self explanatory.

NAO-ENSO-T composites



Forecast charts for the NAO index, along with several other indices, are available from the CPC website. I will show an example of the NAO forecasts only, below, as an example. Figure 9 is the observed NAO index during the previous 4 month time period.

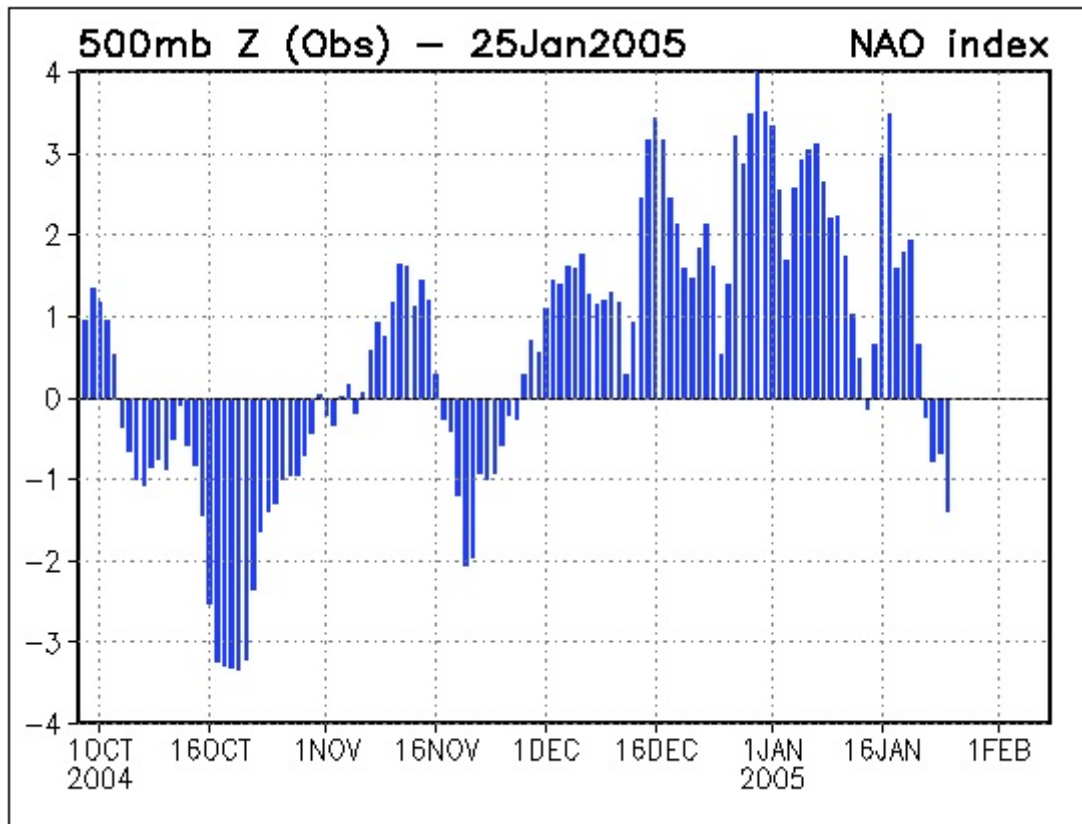


Fig 9. Observed NAO index for the previous 4 month period. The bars are presented as actual plot on a daily basis.

A plot, shown in Figure 10, is also available using a 15 day moving average. The moving average is used as a way to smooth out some of the atmospheric noise from the plot.

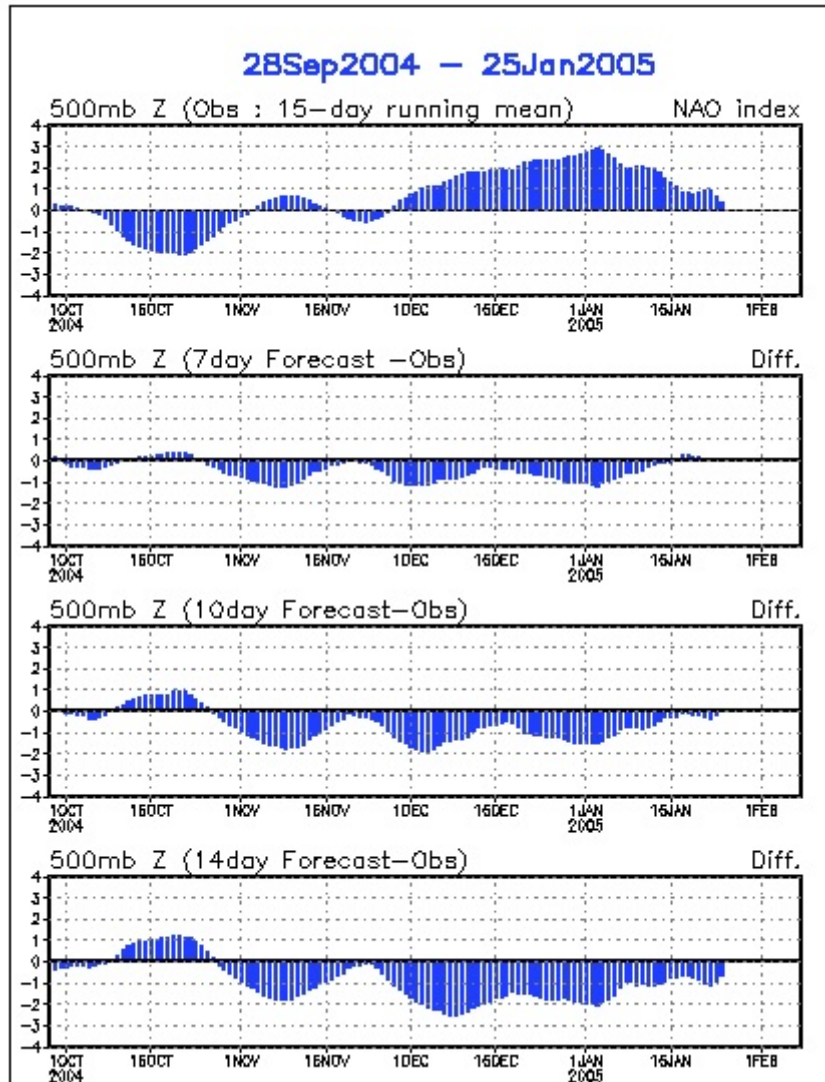


Fig 10. Differences between 15-day running mean values of the observation and the Ensemble mean outlooks. The observed is shown on top, with the 7 day, 10 day, and 14 day forecasts shown successively below.

Forecasts of the NAO index are available in two forms. The first, figure 11, is the actual forecast taken directly from the GFS model. The second form, figure 12, is taken from the from the ensemble runs of the GFS.

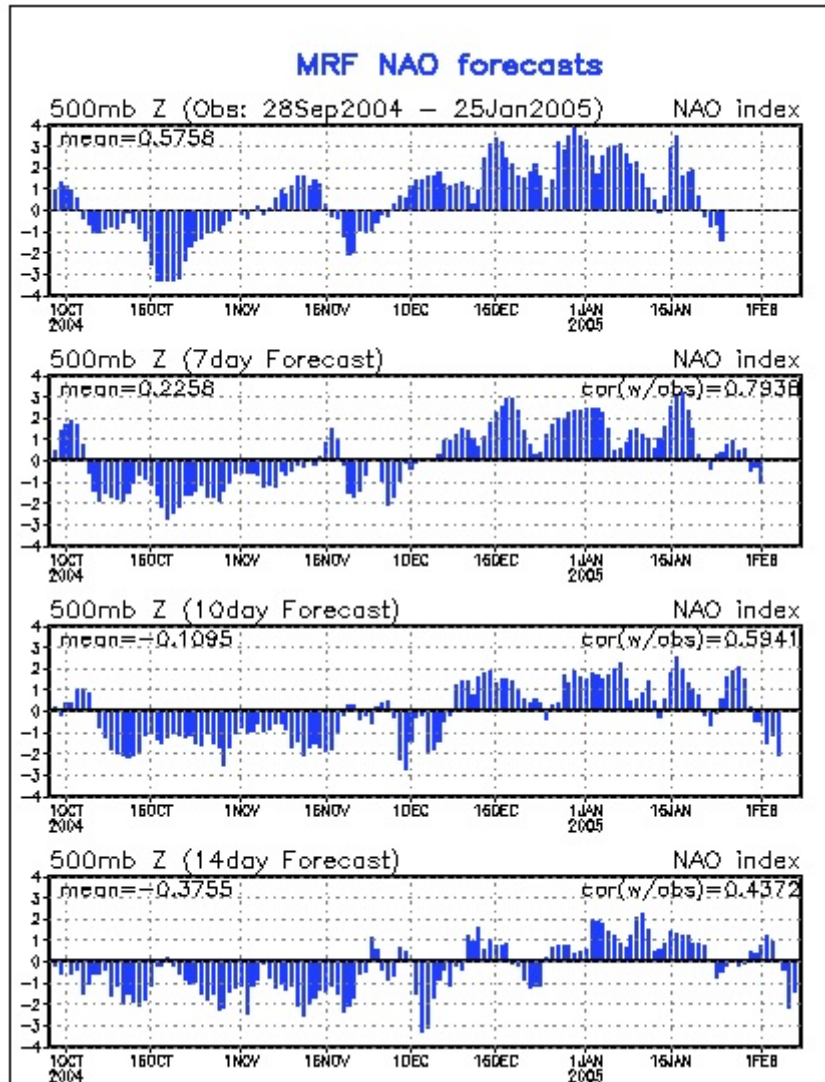


Fig 11. GFS forecasts of NAO index shown in 4 panels. Presentation is the same as in fig 9.

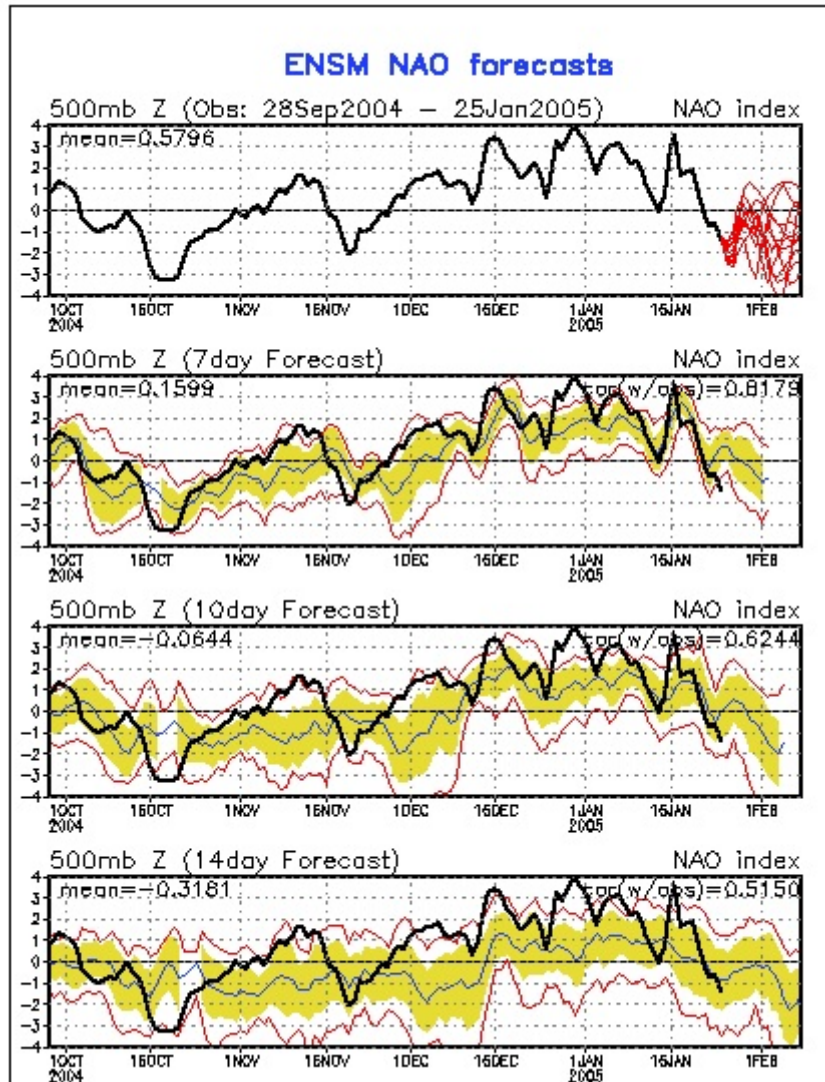
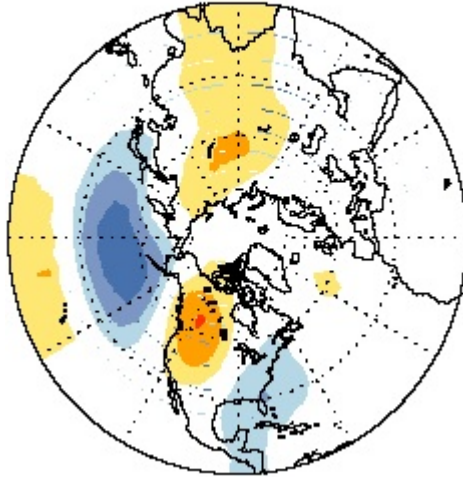


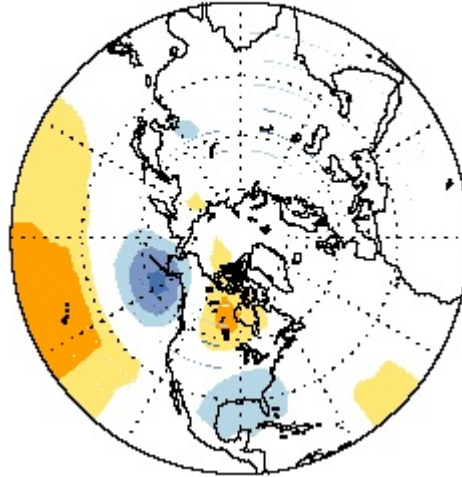
Fig 12. GFS ensemble forecasts of NAO index shown in 4 panels. Presentation is the same as in fig 9.

Pacific North America (PNA) PACIFIC/NORTH AMERICAN PATTERN (PNA)

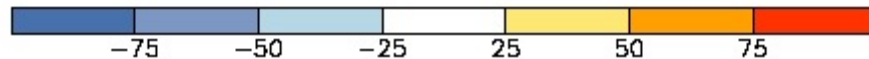
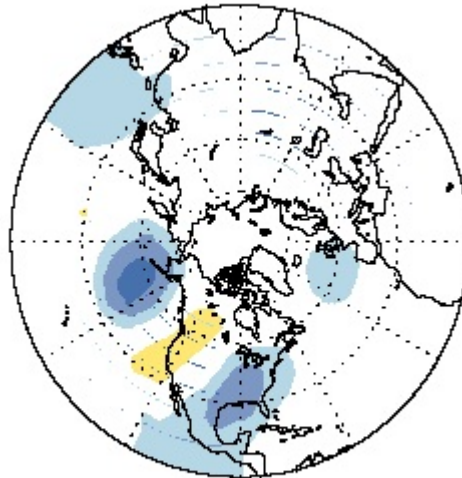
January



April



October



The PNA pattern is one of the most prominent modes of low-frequency variability in the Northern Hemisphere extratropics, appearing in all months except June and July. The PNA pattern reflects a quadrupole pattern of height anomalies, with anomalies of similar sign located south of the Aleutian Islands and over the southeastern United States. Anomalies with sign opposite to the Aleutian center are located in the vicinity of Hawaii, and over the intermountain region of North America (central Canada) during the Winter and Fall (Spring).

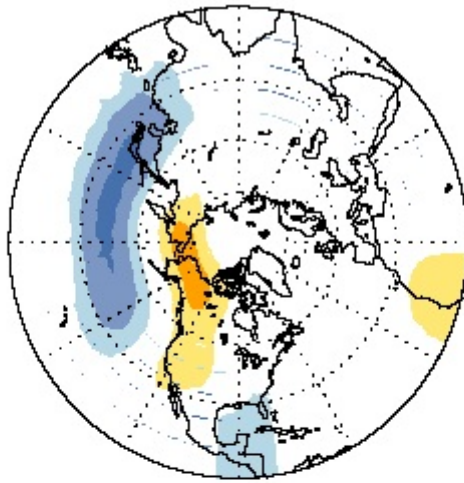
The spatial scale of the PNA pattern is most expansive in Winter. During this period, the Aleutian center spans most of the northern latitudes of the North Pacific. In Spring, the Aleutian center contracts and becomes confined primarily

to the Gulf of Alaska. However, the subtropical center near Hawaii reaches maximum amplitude during the spring. The PNA pattern then disappears during June and July, but reappears in the late summer and fall. During this period, the midlatitude centers become dominant and appear as a wave pattern emanating from the eastern North Pacific. The subtropical center near Hawaii is weakest during this period.

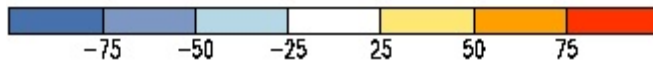
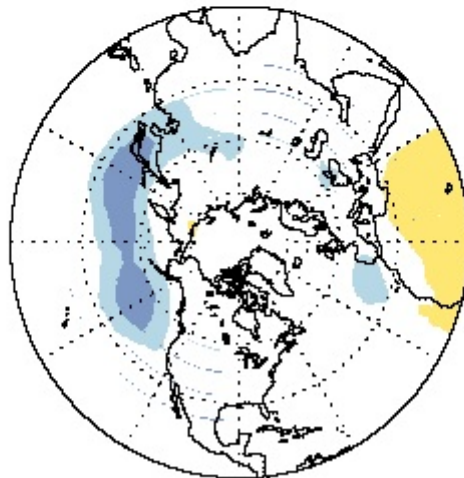
The time series of the PNA pattern also indicates substantial interseasonal, interannual and interdecadal variability. For example, a negative phase of the pattern dominated the period from 1964-1967, while a positive phase of the pattern tended to dominate from 1976-1988. A negative phase of the PNA then dominated during the 1989-1990 period, followed by a prolonged positive phase from fall 1991- early spring 1993.

North Pacific Pattern

April



July



The North Pacific pattern is prominent from March through July. This pattern consists of a primary anomaly center which spans the central latitudes of the western and central North Pacific, and weaker anomaly region of opposite sign which spans eastern Siberia, Alaska and the intermountain region of North America. Overall, pronounced positive phases of the NP pattern are associated with a southward shift and intensification of the Pacific jet stream from eastern Asia to the eastern North Pacific, followed downstream by an enhanced anticyclonic circulation over western North America, and by an enhanced cyclonic circulation over the southeastern United States. Pronounced negative phases of the NP pattern are associated with circulation anomalies of opposite sign in these regions.

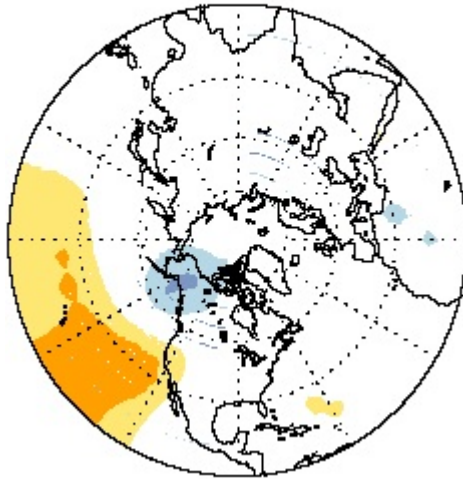
Bell and Janowiak (1995) recently noted that a positive phase of the NP pattern reflects one of the preferred responses of the extratropical atmospheric circulation to ENSO during the Northern Hemisphere spring. This response was particularly evident during the 1992 and 1993 spring seasons, when a prolonged positive phase of the NP pattern dominated the circulation.

Bell and Janowiak also note that the atmospheric circulation during the several month period prior to the onset of the Midwest floods of June-July 1993 was dominated by the most pronounced and persistent positive phase of the NP pattern in the historical record. Their study concluded that these conditions were indirectly important to the onset and overall magnitude of the floods, since they fostered an anomalously intense storm track over the midlatitudes of the North Pacific. Dramatic changes in this storm track during June then ultimately initiated the Midwest floods.

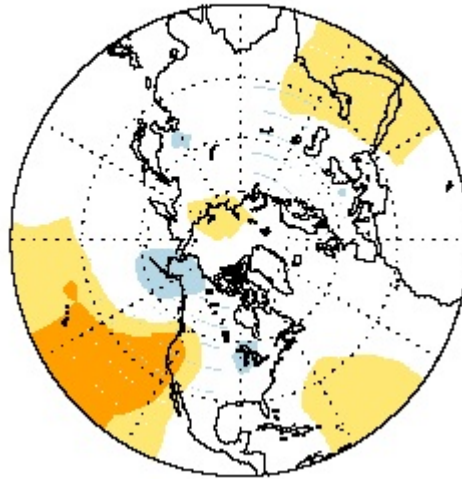
East Pacific Pattern

EAST PACIFIC PATTERN (EP)

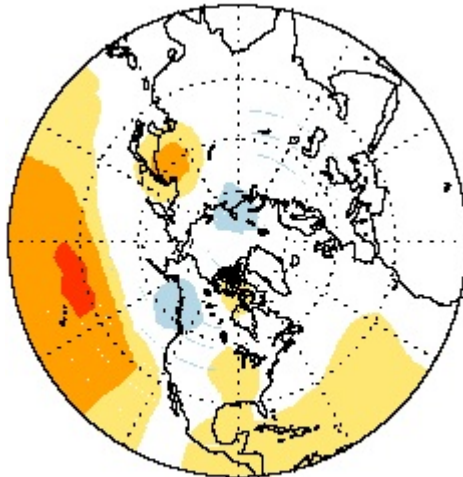
January



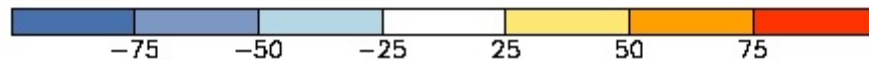
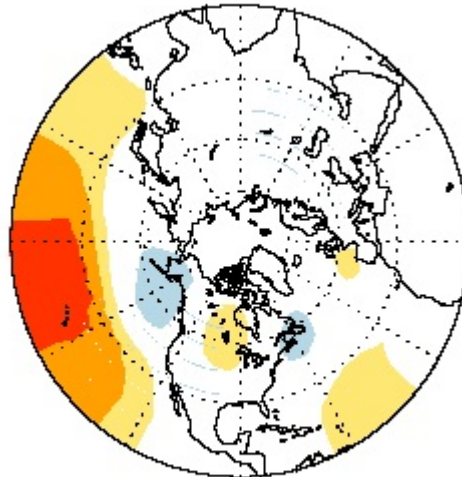
April



July



October



The EP pattern is evident in all months except August and September, and reflects a north-south dipole of height anomalies over the eastern North Pacific. The northern center is located in the vicinity of Alaska and the west coast of Canada, while the southern center is of opposite sign and is found near, or east of, Hawaii. During strong positive phases of the EP pattern, a deeper than normal trough is located in the vicinity of the Gulf of Alaska/ western North America, and positive height anomalies are observed farther south. This phase of the pattern is associated with a pronounced northeastward extension of the Pacific jet stream toward western North America, and with enhanced westerlies over the Pacific Northwest States, northern California, and sometimes southwestern British Columbia.

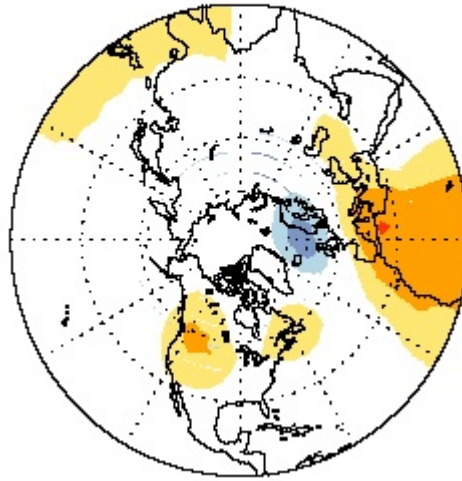
In contrast, strong negative phases of the EP pattern are associated with a pronounced split-flow configuration over the eastern North Pacific, and with reduced westerlies throughout the region. This circulation is accompanied by a confinement of the climatological mean Pacific trough to the western North Pacific, and possibly with a blocking flow configuration farther east.

The most persistent positive phase of the EP-Jet pattern occurred from 1973-1975, and the most persistent negative phase of the pattern occurred from early 1992 through mid-1993. This latter period was dominated by warm episode conditions in the equatorial Pacific, and by two distinct periods of mature ENSO conditions. During this period, the subtropical jet stream was generally stronger than normal and displaced well east of its climatological -mean position toward the southwestern United States. These conditions contributed to an end of prolonged drought conditions in California (Bell and Basist 1994), and brought abundant precipitation to the southwestern United States, particularly during the 1992/93 winter. These conditions were also associated with generally above-normal precipitation over the central United States during the year preceding the onset of the Midwest floods of June-July 1993 (Bell and Janowiak 1995, Chagnon 1996). This enhanced precipitation then contributed to above-normal soil moisture levels throughout the Midwest during the period, and to near-saturated soil conditions just prior to the onset of the floods.

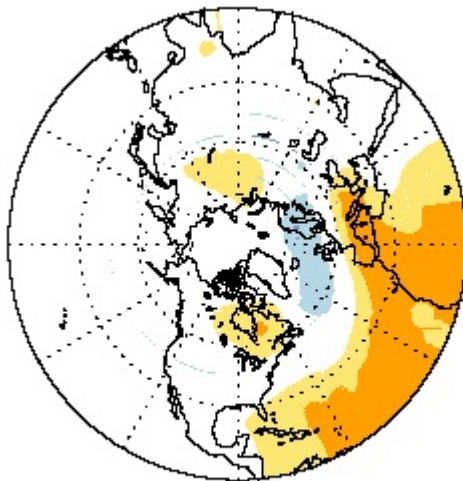
East Atlantic Jet Pattern

EAST ATLANTIC JET (EA-JET)

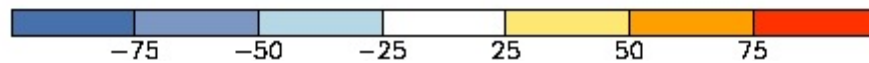
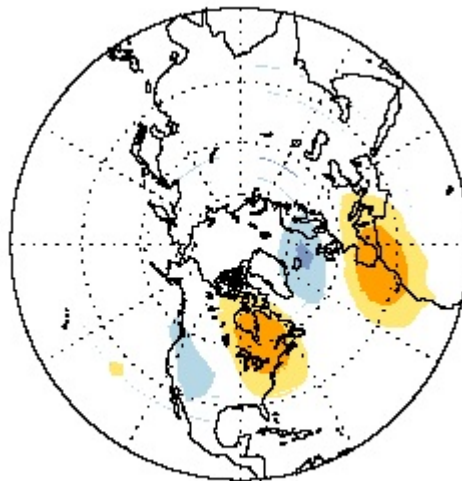
April



July



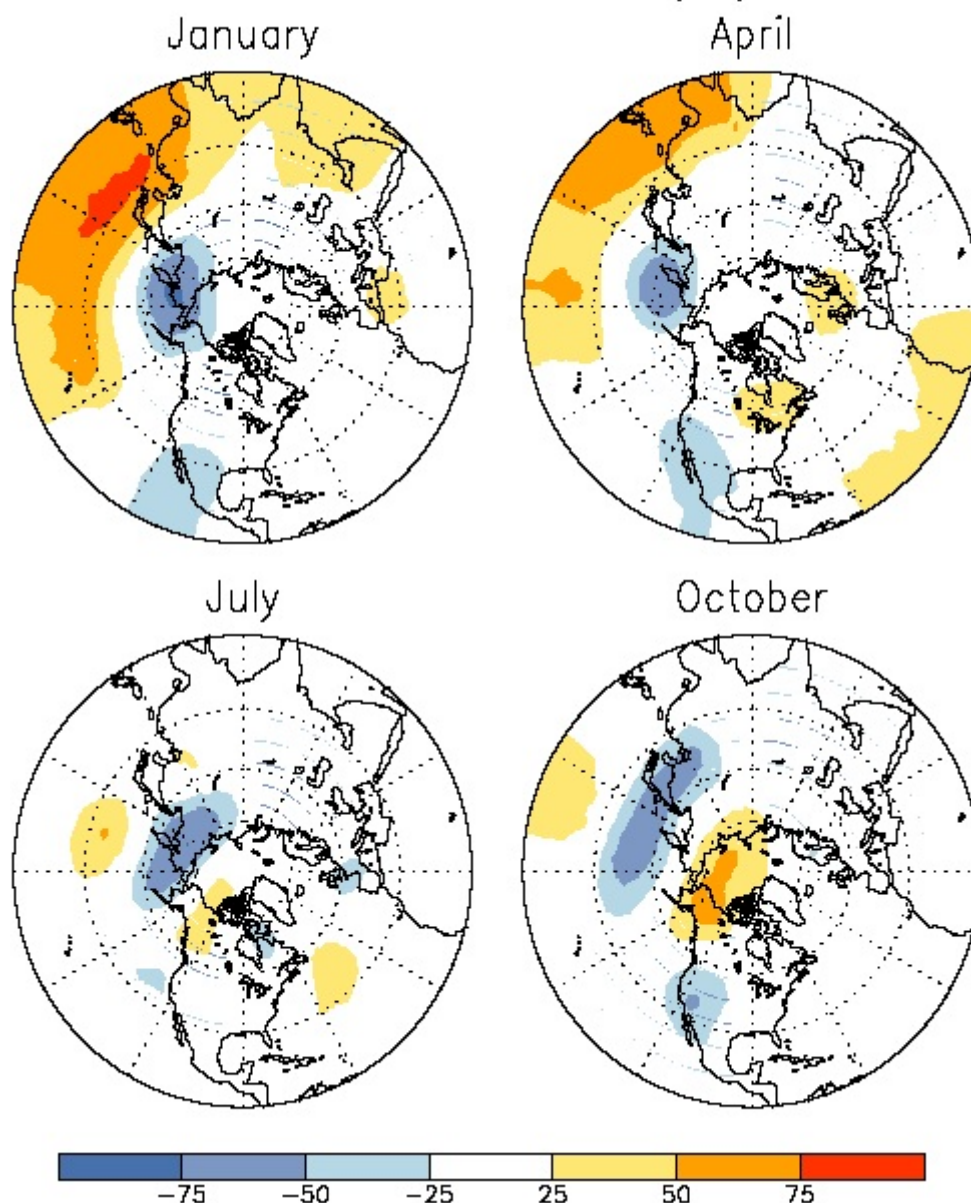
October



The East Atlantic Jet pattern is the third primary mode of low frequency variability found over the North Atlantic, appearing between April and August. This pattern also consists of a north-south dipole of anomaly centers, with one main center located over the high latitudes of the eastern North Atlantic and Scandinavia, and the other center located over Northern Africa and the Mediterranean Sea. A positive phase of the EA-Jet pattern reflects an intensification of westerlies over the central latitudes of the eastern North Atlantic and over much of Europe, while a negative phase reflects a strong split-flow configuration over these regions, sometimes in association with long-lived blocking anticyclones in the vicinity of Greenland and Great Britain

The time series of the EA-jet pattern exhibits considerable interdecadal variability. For example, the 1971-1978 period is dominated by the negative phase of the pattern, while the 1985-1993 period is dominated by the positive phase of the pattern. In fact, from 1986-1993 the positive phase of the pattern was observed nearly 70% of the time.

West Pacific Pattern WEST PACIFIC PATTERN (WP)



The WP pattern is a primary mode of low-frequency variability over the North Pacific in all months, and has been previously described by both Barnston and Livezey (1987) and Wallace and Gutzler (1981). During winter and spring, the pattern consists of a north-south dipole of anomalies, with one center located over the Kamchatka Peninsula and another broad center of opposite sign covering

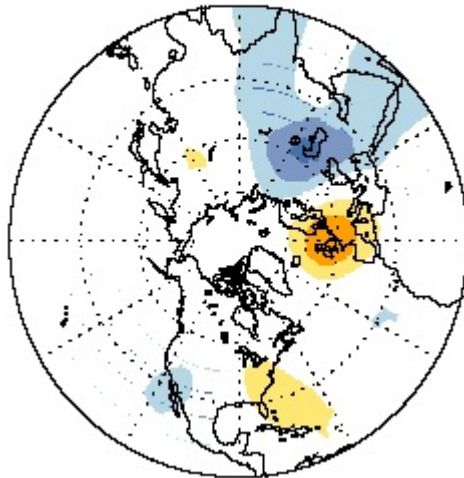
portions of southeastern Asia and the low latitudes of the extreme western North Pacific. Therefore, strong positive or negative phases of this pattern reflect pronounced zonal and meridional variations in the location and intensity of the entrance region of the Pacific (or East Asian) jet stream.

In the summer and fall, the WP pattern becomes increasingly wave-like, and a third prominent center appears over Alaska and the Beaufort Sea, with a sign opposite to the center over the western North Pacific. This wave structure is most evident in the Fall, when it extends downstream along a quasi great-circle route into the western United States. The time series of the WP pattern indicates considerable intermonthly and interannual variability, and persistence of a particular phase of the pattern is relatively common.

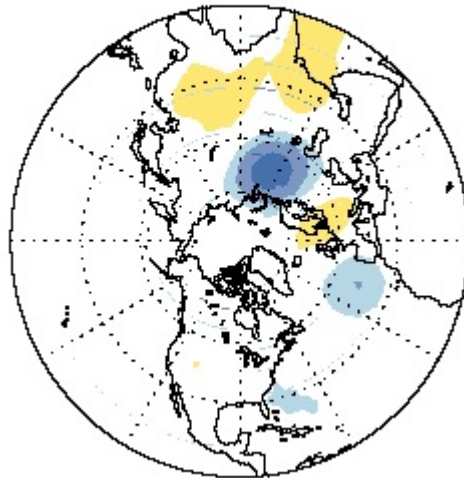
East Atlantic/West Russia Pattern

EAST ATLANTIC/ WEST RUSSIA (EATL/WRUS)

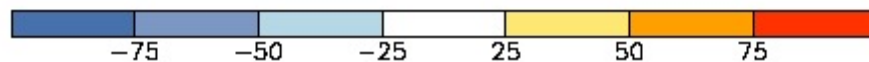
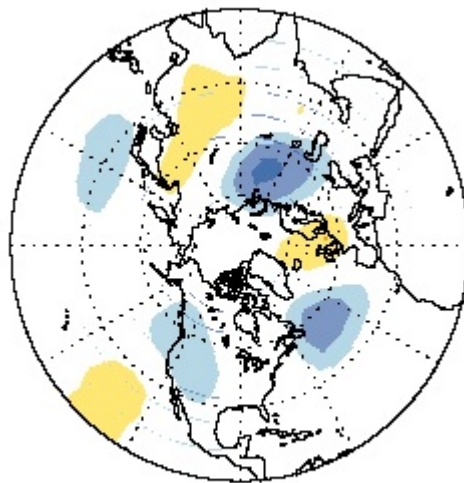
January



April



October



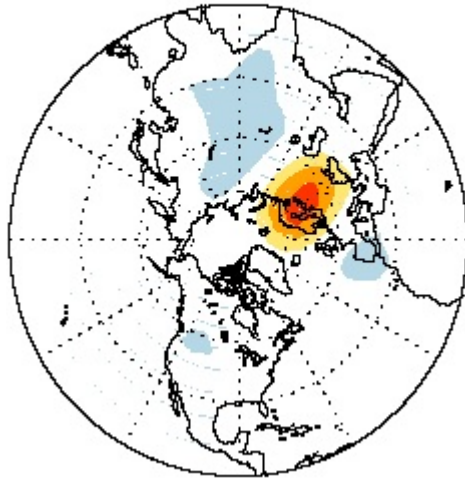
The East Atlantic/ West Russia (EATL/WRUS) pattern is one of two prominent that affects Eurasia during most of the year. This pattern is prominent in all months except June-August, and has been referred to as the Eurasia-2 pattern by Barnston and Livezey (1987). In Winter, two main anomaly centers, located over the Caspian Sea and western Europe, comprise the East Atlantic/ West Russia pattern. A three-celled pattern is then evident in the spring and fall seasons, with two main anomaly centers of opposite sign located over western/ north-western Russia and over northwestern Europe. The third center, having same sign as the Russia center, is located off the Portuguese coast in spring, but exhibits a pronounced retrogression toward Newfoundland in the fall.

The most pronounced and persistent negative phases of the East Atlantic/ West Russia pattern tend to occur in winter and early spring, with particularly large negative phases noted during the winters and early springs of 1969/70, 1976/77 and 1978/79. Pronounced positive phases of the pattern are less common, with the most prominent positive phase evident during late winter/ early spring of 1992/93. During this 1992/93 winter, negative height anomalies were observed throughout western and southwestern Russia, and positive height anomalies were observed throughout Europe and the eastern North Atlantic. These conditions were accompanied by warmer and wetter than normal conditions over large portions of Scandinavia and northwestern Russia, and by much colder and drier than normal conditions over the eastern Mediterranean Sea and the Middle East. During MAM 1993, the area of negative anomalies over western Russia persisted, the positive anomaly center over northwestern Europe became consolidated, and a negative anomaly center became established over the eastern North Atlantic. These conditions brought a continuation of warmer (colder) than normal conditions to Scandinavia (eastern Mediterranean Sea sector), and drier than normal conditions to much of Europe.

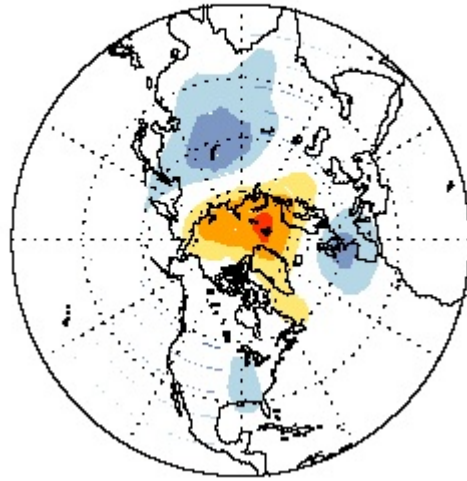
Scandinavia Pattern

SCANDINAVIA (SCAND)

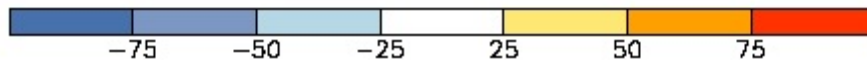
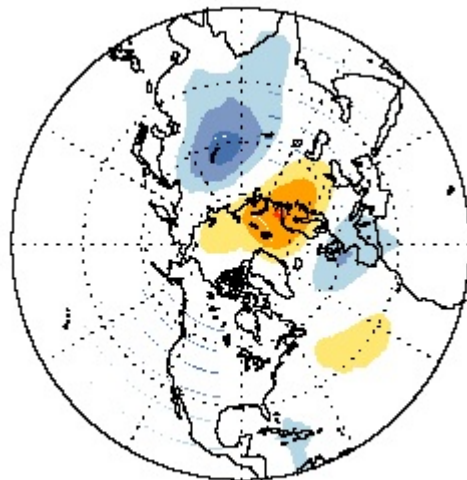
January



April



October

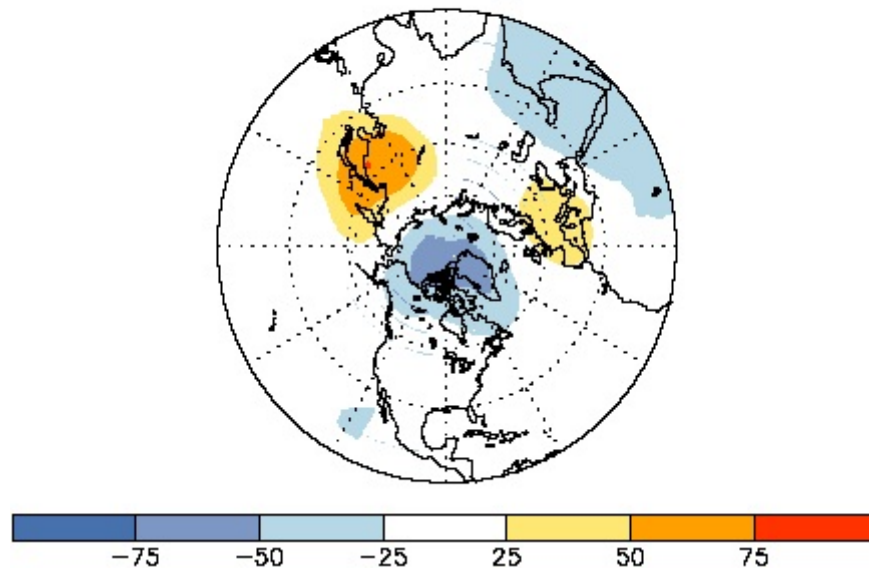


The Scandinavia pattern (SCAND) consists of a primary circulation center which spans Scandinavia and large portions of the Arctic Ocean north of Siberia. Two additional weaker centers with opposite sign to the Scandinavia center are located over western Europe and over the Mongolia/ western China sector. The Scandinavia pattern is a prominent mode of low frequency variability in all months except June and July, and has been previously referred to as the Eurasia-1 pattern by Barnston and Livezey (1987). The positive phase of this pattern is associated with positive height anomalies, sometimes reflecting major blocking anticyclones, over Scandinavia and western Russia, while the negative phase of the pattern is associated with negative height anomalies over these regions.

The time series for the Scandinavia pattern also exhibits relatively large interseasonal, interannual and interdecadal variability. For example, a negative phase of the pattern dominated the circulation from early 1964 through mid-1968 and from mid-1986 through early 1993. Negative phases of the pattern have also been prominent during winter 1988/89, spring 1990, and winter/spring 1991/92. In contrast, positive phases of the pattern were observed during much of 1972, 1976 and 1984.

Polar/Eurasian Pattern

POLAR/ EURASIAN PATTERN
January



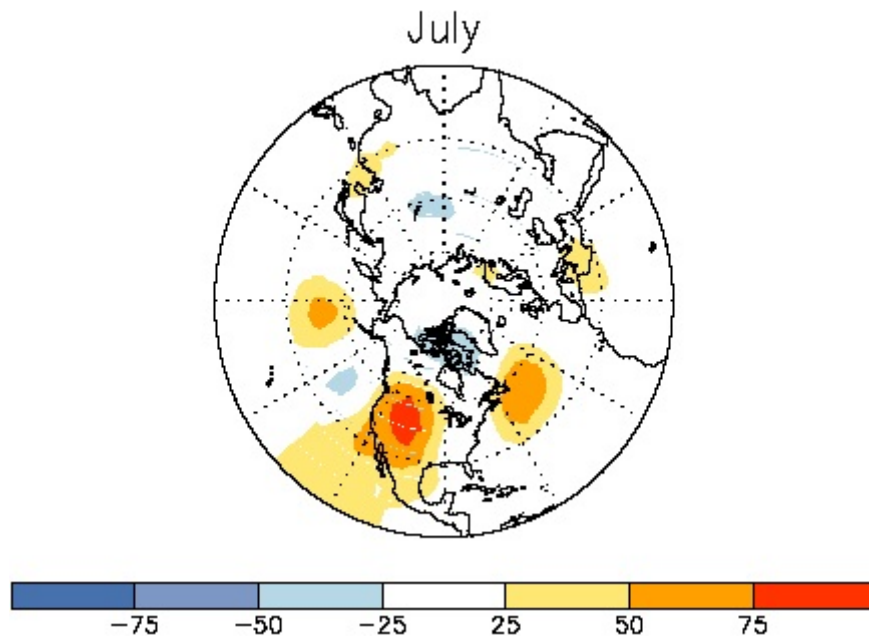
The Polar/ Eurasian pattern appears only in the winter, and is the most prominent mode of low-frequency variability during December and February. The pattern consists of one main anomaly center over the polar region, and separate centers of opposite sign to the polar anomaly over Europe and northeastern China. Thus, the pattern reflects major changes in the strength of the circumpolar circulation, and reveals the accompanying systematic changes which occur in the midlatitude circulation over large portions of Europe and Asia.

The polar/Eurasian pattern exhibits strong intradecadal and interdecadal variability, with several consecutive winters of a positive phase of the pattern often followed by several winters having a negative phase of the pattern. For example, the winters from 1964/65 through 1969/70 were dominated by a negative phase of the pattern, followed by a five-year period from 1971/72 through 1975/76 dominated by a positive phase of the pattern. A negative phase then returned for much of the decade between 1976/77 and 1985/86, followed by a prolonged positive phase of the pattern from 1988/89 through 1992/93. These prolonged positive phases of the pattern reflected below-normal heights throughout the polar region and an enhanced circumpolar vortex, in combination with above-normal heights over much of Europe and eastern Asia. In contrast, the

prolonged negative phases of the pattern reflected above-normal heights throughout the polar region and a weaker than normal polar vortex, in combination with below-normal heights over much of Europe and eastern Asia.

The following two patterns do not have as strong a correlation with the weather patterns as the previous patterns, however at the times they are important they may have strong effects on the western U.S. and Alaska.

Pacific Transition Pattern PACIFIC TRANSITION PATTERN



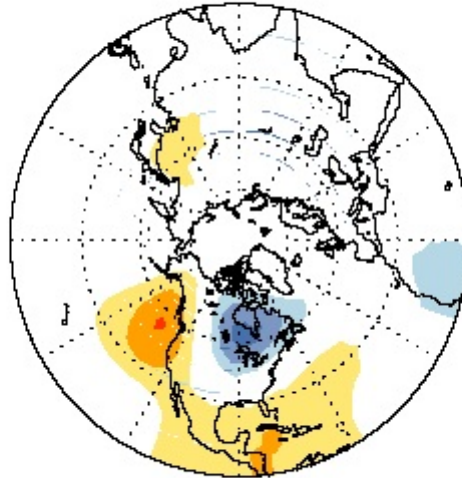
The Pacific Transition pattern is prominent between May-August. The mode consists of a wave-like pattern of height anomalies, which extends from the Gulf of Alaska eastward to the Labrador Sea, and is aligned along the 40°N latitude circle. The prominent centers of action have a similar sign, and are located over the intermountain region of the United States and over the Labrador Sea. Relatively weak anomaly centers with signs opposite to the above are located over the Gulf of Alaska and over the eastern United States.

Two of the most pronounced negative phases of the PT pattern in the historical record occurred during July 1992 and July 1993. During each of these periods, well below-normal 500-mb heights were observed over the northwestern United States, in association with a substantially reduced strength of the climatological mean ridge, which is located over this region in Summer. Below-normal heights were also observed over the Canadian Maritime Provinces and over the central North Pacific during these months, while above-normal heights were observed over the Gulf of Alaska. During July 1993, these extremely anomalous conditions were associated with a continuation of record flooding throughout the Midwest United States (Bell and Janowiak 1995).

Tropical/Northern Hemisphere Pattern

TROPICAL/ NORTHERN HEMISPHERE PATTERN

January



The Tropical/ Northern Hemisphere pattern was first classified by Mo and Livezey (1986), and appears as a prominent mode from November-February. The pattern consists of one primary anomaly center over the Gulf of Alaska and a separate anomaly center of opposite sign over the Hudson Bay. A weaker area of anomalies having similar sign to the Gulf of Alaska anomaly extends across Mexico and the extreme southeastern United States. This pattern reflects large-scale changes in both the location and eastward extent of the Pacific jet stream, and also in the strength and position of the climatological mean Hudson Bay Low. Thus, the pattern significantly modulates the flow of marine air into North America, as well as the southward transport of cold Canadian air into the north-central United States.

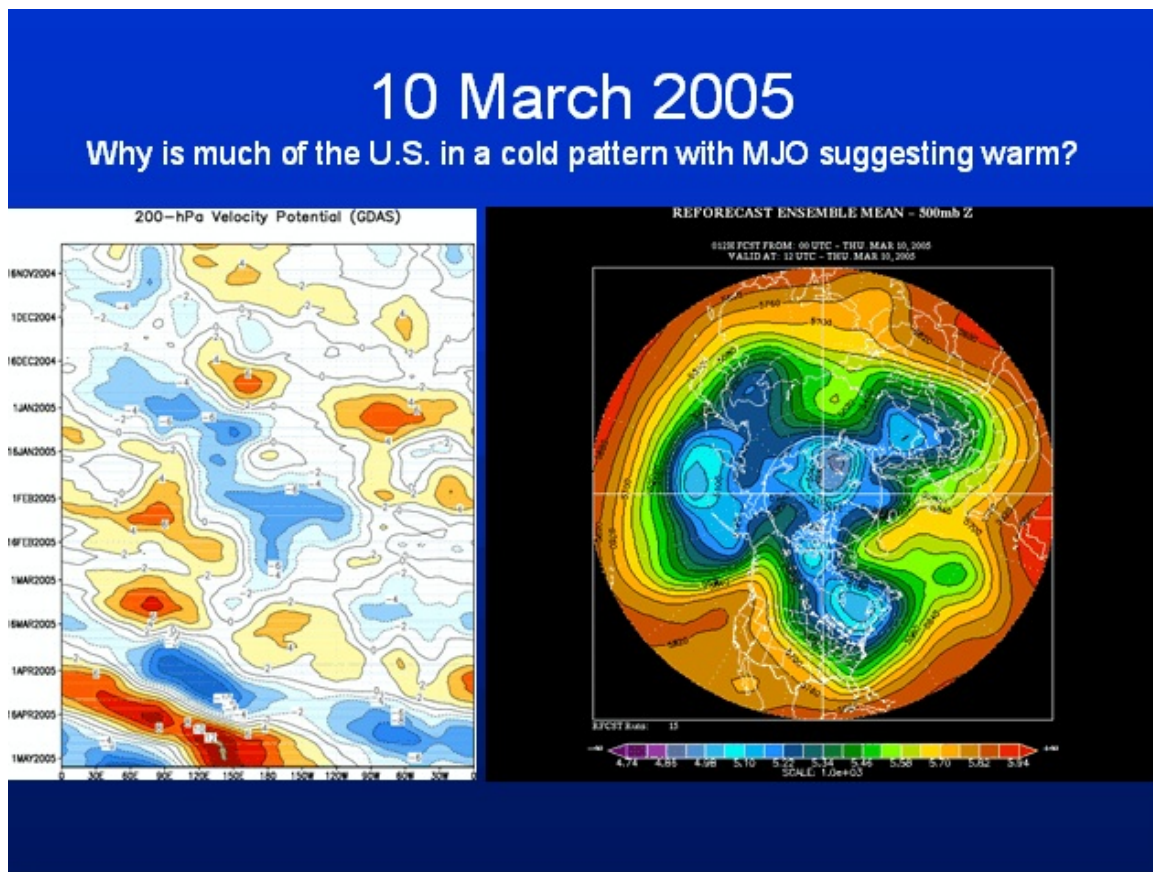
Pronounced negative phases of the TNH pattern are often observed during December and January when Pacific warm (ENSO) episode conditions are present (Barnston et al. 1991). One recent example of this is the 1994/95 winter season, when mature Pacific warm episode conditions and a strong negative phase of the TNH pattern were present. During this period, the mean Hudson Bay trough was much weaker than normal and shifted northeastward toward the Labrador Sea. Additionally, the Pacific jet stream was much stronger than normal and shifted southward to central California, well south of its climatological mean position in the Pacific Northwest. This flow pattern brought well above-normal temperatures to eastern North America and above-normal rainfall to the southwestern United States.

In contrast, positive phases of the TNH pattern tend to accompany Pacific cold events. An example is the very persistent positive phase of the TNH pattern

during 1988/89 -1990/91, which developed in apparent association with the strong 1988/89 Pacific cold event.

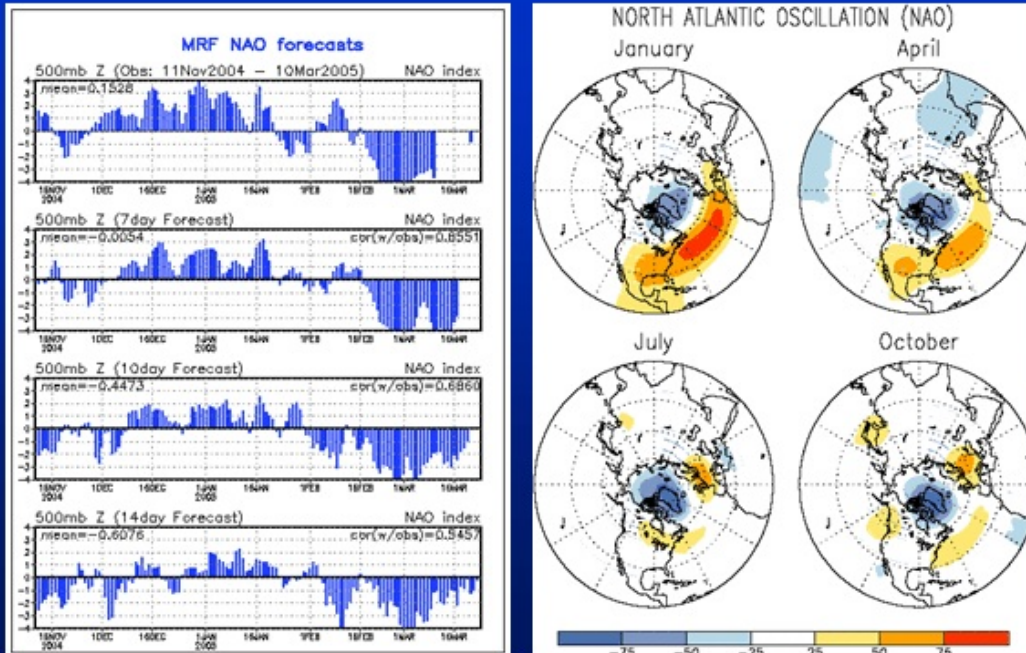
Will using the MJO and various teleconnections guarantee you a perfect forecast? The answer is, certainly not. The advantage of using these tools is that you will be able to make more sound decisions and judgments as you look at the numerical model output, especially in the medium and longer range. This will become more important as we move into more active involvement with the forecast in the 8 to 14 day timeframe.

I'd like to go over a few cases briefly to show the potential of using the information presented here. I chose several cases to go through fairly briefly to demonstrate not only how the information can be useful, but to show there is a linkage between the intraseasonal indices and the forecast process. Also, note I was able to find not just one, but 5 cases over a period of just two months.



From the 200 hPa Velocity Potential chart shown on the left, we can see that for 10 March it would appear we were around index 7 as far as MJO, or at least MJO like convection, was concerned. If that was the only thing you looked at, you would expect the weather to be warm. Indeed, this was not the case. How can that happen?

NAO dominated – The very strong “–” NAO overcame the MJO signal



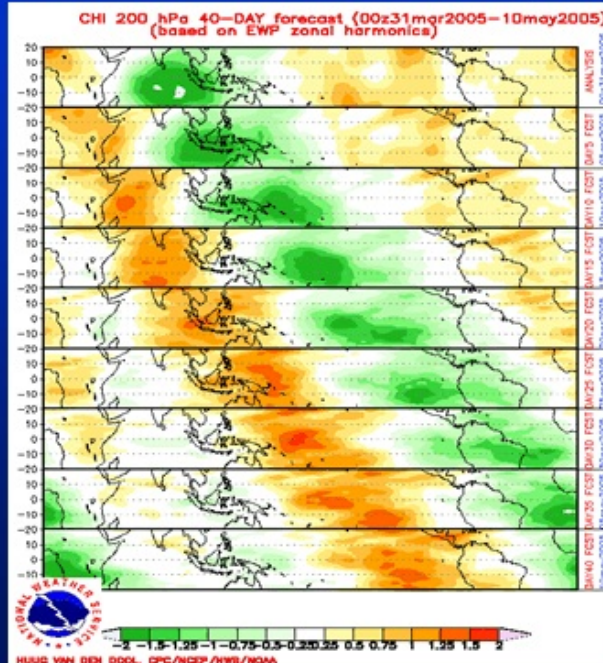
Note – Map of NAO is for positive phase. Therefore, the effect of NAO is opposite of what the teleconnection shows. During El Nino, the MJO typically will have less effect on CONUS weather. We can see from the charts on the left that NAO was very strongly negative, so much so that it had more influence on the weather over the CONUS than did MJO.

With the indices in opposition, it is difficult to know which one to go with.

- Clearly, MJO suggested above normal temperatures
- MJO was in index 7. Recall that index 3-8 is usually warm over the eastern CONUS
- NAO also has a strong impact on eastern North America
- We saw that NAO turned strongly negative
- MJO has less effect on the CONUS during El Nino events and the winter of 2004-05 was in weak El Nino.
- In this case, the weak El Nino would give the clue to watch for stronger influences on the part of NAO.

31 March 2005

MJO would seem to indicate a cold period here.

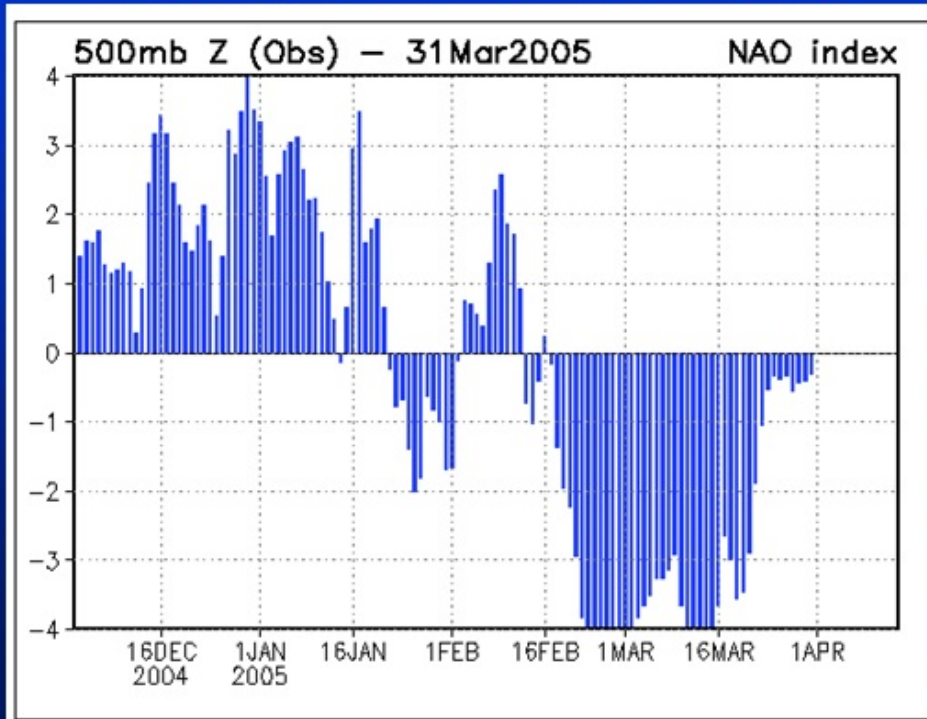


Though there is a response to the ongoing phase of MJO, the cold air penetration is not as strong as would normally be expected owing to the recent NAO activity. One Should check the position of MJO against the backdrop of NAO. Keep in mind here, this chart is from the EWP and tends to propagate tropical convection eastward too fast.

Let's take a look at what we have here:

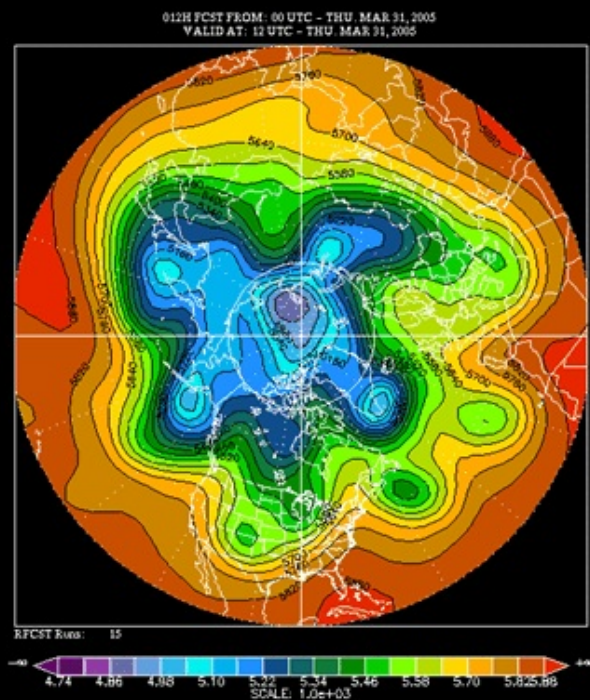
- MJO is in Index 1
- Index 9, 10, and 1 are typically colder than normal over much of CR
- NAO has shown rapid change from strong negative to near neutral
- El Nino remains weak
- One would expect NAO to have a significant influence and temper the effects of MJO somewhat.

Note the rapid return of NAO to near neutral



Atmospheric response – Neutral NAO with MJO at Index 1
500 Mb for 12 UTC 31 Mar 2005

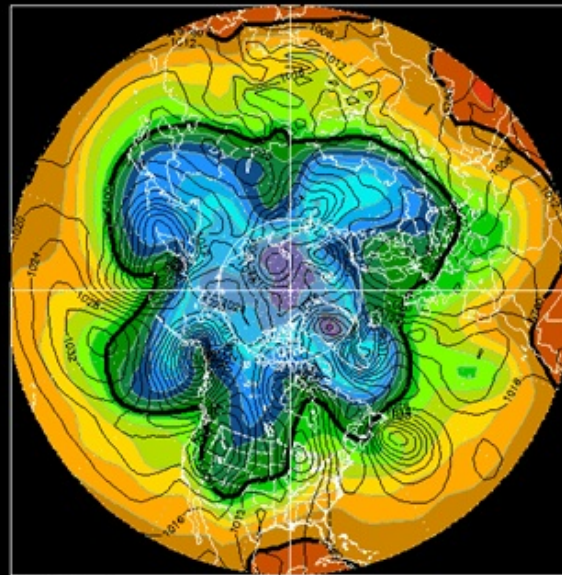
REFORECAST ENSEMBLE MEAN - 500mb Z



Atmospheric response – Neutral NAO with MJO at Index 1
SFC for 12 UTC 31 Mar 2005

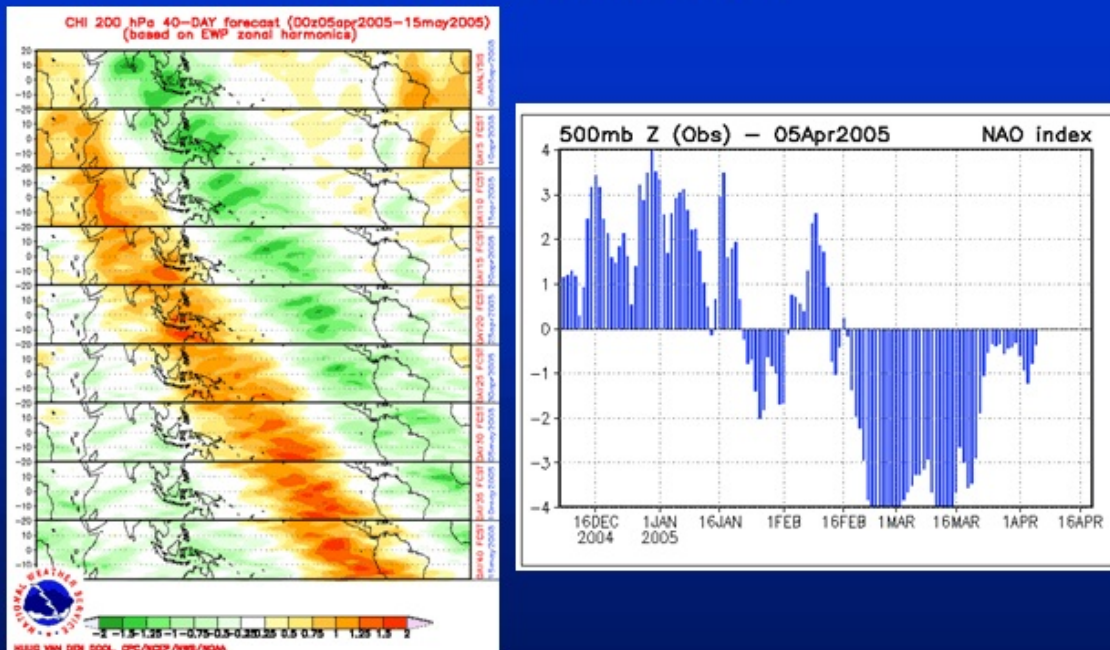
REFORECAST ENS. MEAN – MSLP(mb)/1000:500mb THK

012H FCST FROM: 00 UTC - THU. MAR 31, 2005
VALID AT: 12 UTC - THU. MAR 31, 2005



Note: It was a cool pattern but not extreme.

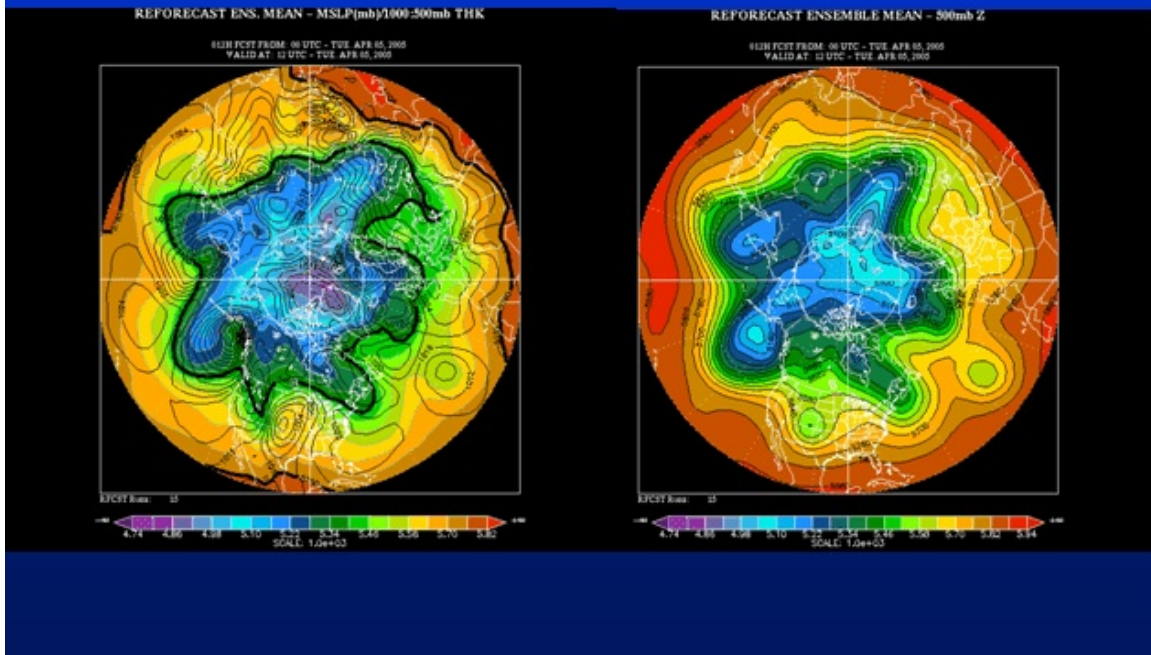
05 April 2005 MJO moves toward index 3



As MJO moves toward index 3, one would expect the response to be for warmer temperatures. Usually a lag of a few days is found; however note the upward trend in the NAO.

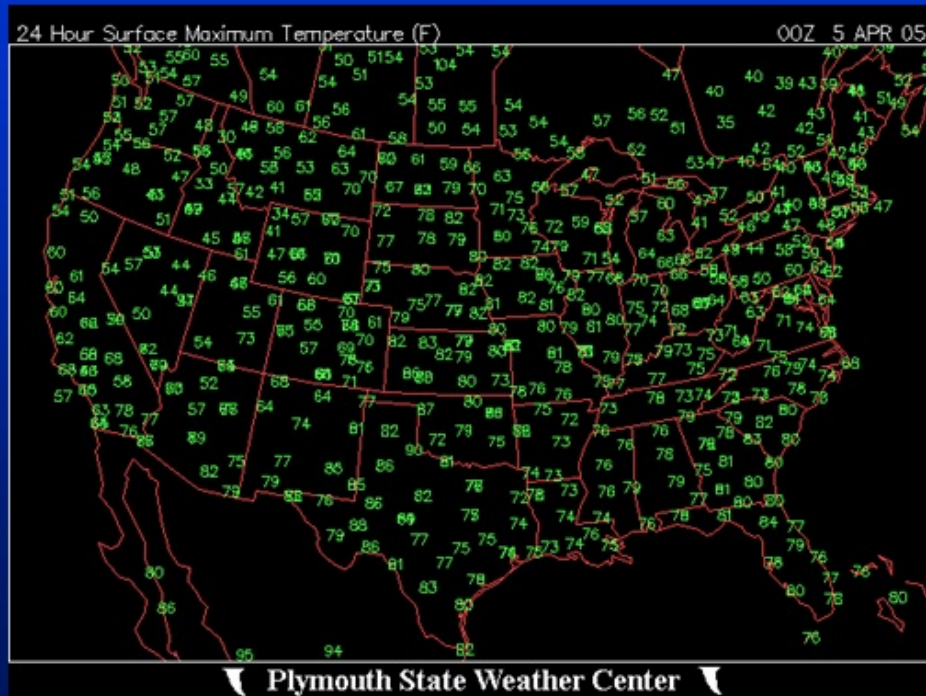
- As MJO moves toward index 3, one would expect the response to be for warmer temperatures. Usually a lag of a few days is found; however note the upward trend in the NAO.
- 500 mb heights rise rapidly and temperatures warm.
- Note the very warm max temps in much of the CONUS, especially the central sections.

Strong response noted at both surface and aloft

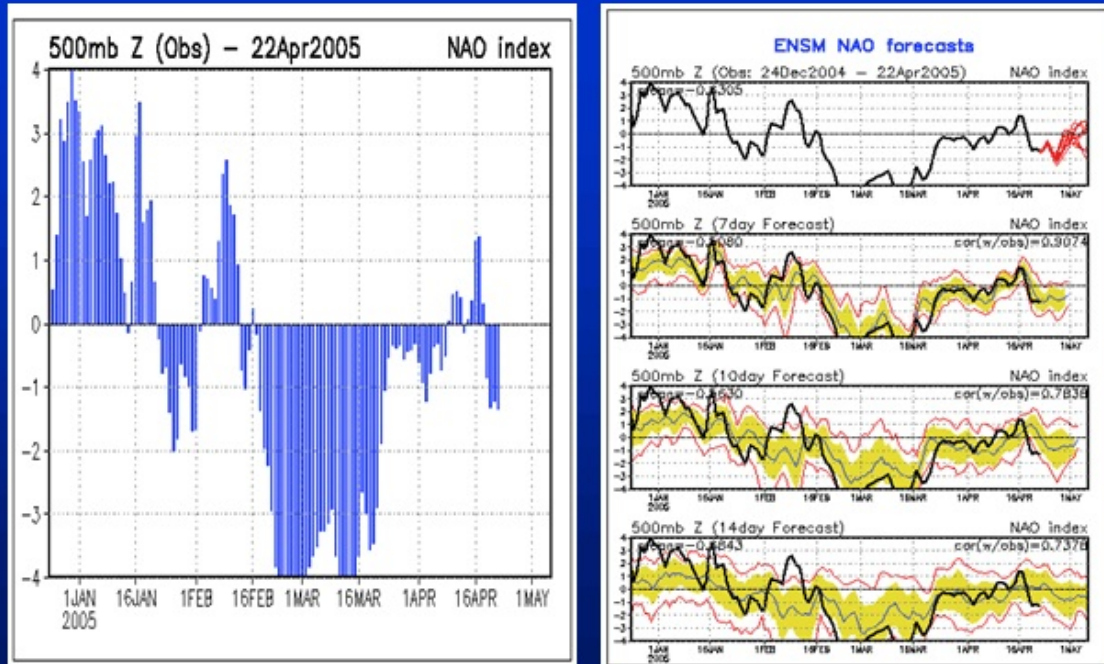


Shown above are the reforecast ensemble MSLP with 1000-500 thickness on the left, and ensemble mean 500 mb height on the right for 12 UTC 05 April 2005. Below are max temperatures for the day. These readings are very much above normal over the central U.S. for example. Note the highs in the 70s and 80s as far north as southeast ND into central MN.

Note the unseasonably warm max temps



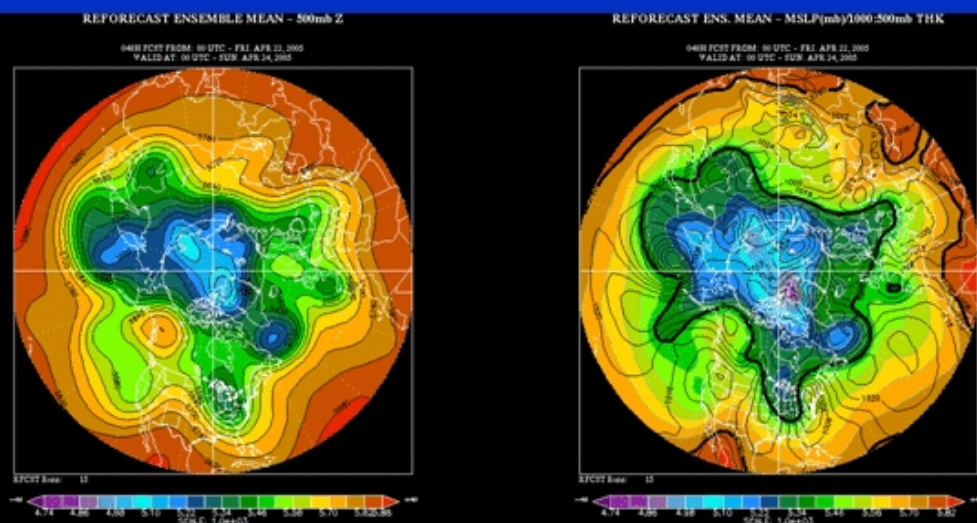
22 April 2005 Case of rapid change in NAO



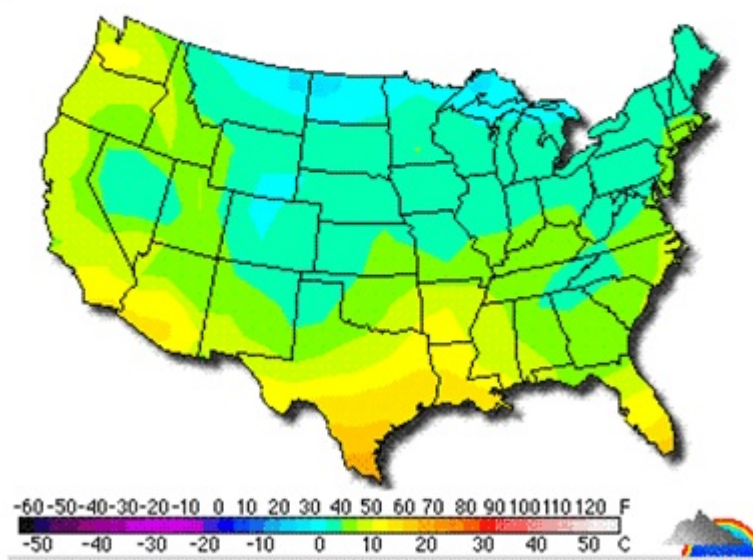
Note the rapid change back to a negative NAO (left) and the forecast for the negative phase to last for about 2 weeks.

- MJO is between index 6 and 7 (not shown)
- El Nino remains weak.
- NAO has made a sharp shift into negative territory
- Ensemble progs show a long period of negative NAO
- Result – cooler weather conditions will prevail and in fact a forecast was made for a two week cool period based on these findings.
- An outlook for freezing weather was issued 3 days in advance following a record warm three week period of in late March and early April.

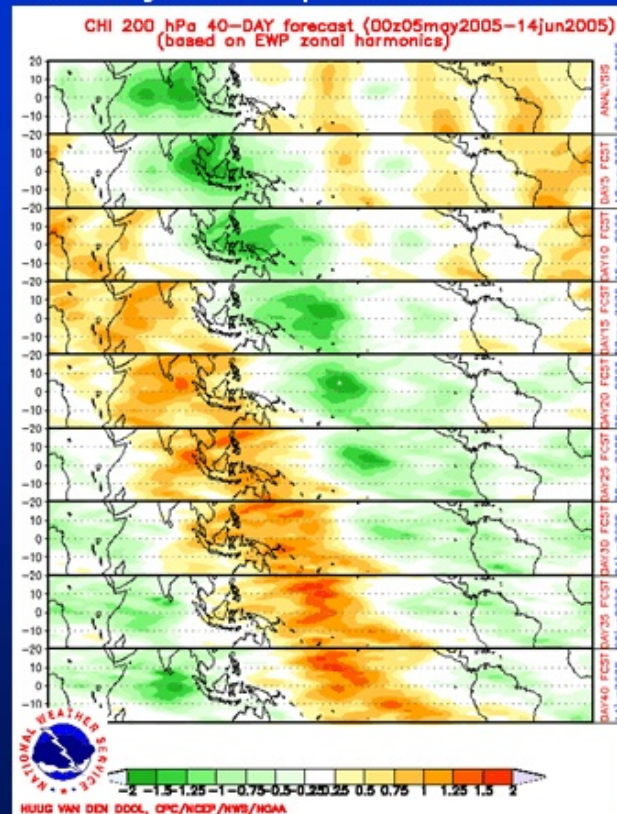
With swing to "-" NAO, note the deepening trough over the eastern U.S. and the southward push of the 540 Dam line 24 April 2005..



Min Temps through 12UTC
24 April 2005



05 May 2005 – pattern reversal



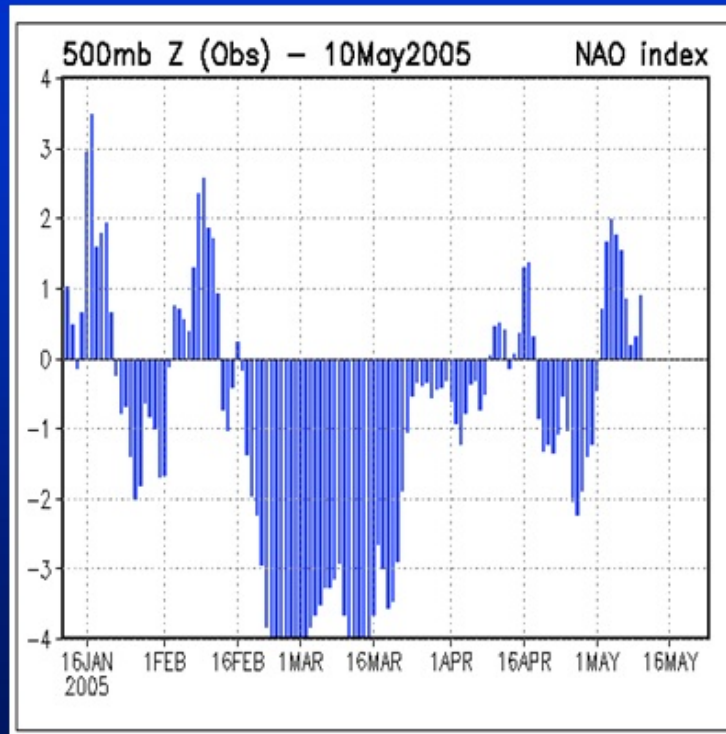
From the EWP chart for 05 May 2005 we can see the MJO convection moving toward western Australia. By 10 May, the MJO is forecast to be into index 3, the beginning of the warm phase for a large part of the central and eastern CONUS. The signal for the change came from the MJO:

- From the EWP chart for 05 May 2005 we can see the MJO convection moving toward western Australia. By 10 May, the MJO is forecast to be into index 3, the beginning of the warm phase for a large part of the central and eastern CONUS.
- Expected Weather conditions moving toward Index 3.

The question is, did the signal portend the future state of the atmosphere?

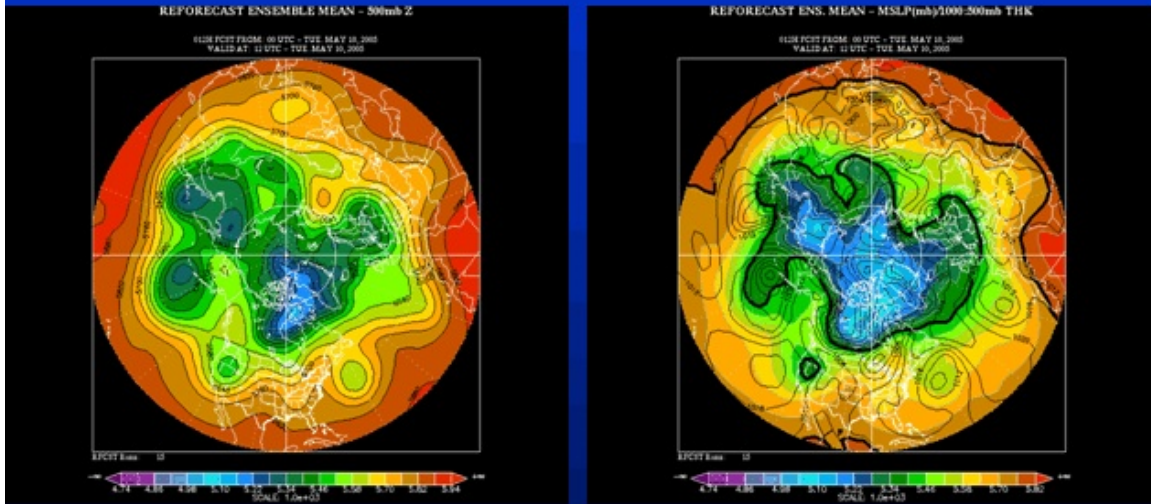
- The answer is yes
- The forecast from the EWP did verify with MJO moving into index 3
- Checking NAO we see the index also went into the positive
- 500 mb heights rose sharply and surface temperature warmed
- Record lows and snow were replaced by well above normal readings and severe weather
- Max temps in the 70s and 80s reached to the Canadian border
- The reversal was placed in forecasts more than a week in advance
- Significant rainfall arrived by the 10th.

Verification for 10 May 2005 - NAO



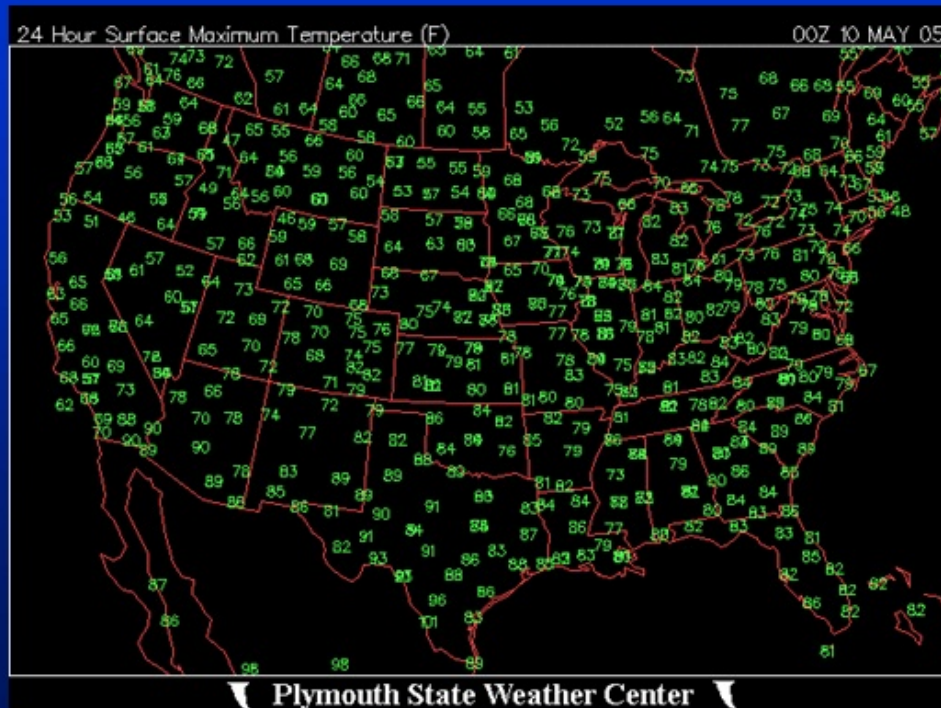
In addition to the east ward shift, we see a sudden change in NAO during the first week of May. The combinations of these two events suggest a strong possibility of a temperature regime reversal.

Atmospheric response to MJO and NAO 12 UTC 10 May 2005



After a record cold snap in late April and early May, the pattern underwent a sudden reversal as NAO flipped from negative to positive and MJO began to move into the index 3 position. This can be seen in the maximum temperature graphic below:

Temperatures responded quickly with a large area above normal.



Finally, I would like to point out a few things that one should always keep in mind:

- Knowing the state of various Intraseasonal Indices can help with the daily forecast.
 - Are various indices in harmony or opposition?
 - Do the model runs fit what is expected based on the indices?
 - Know which index is likely to have the most effect on your area.
- Use of Ensemble information can be helpful, especially clusters that are supported by the current state of Intraseasonal Indices.
- Continuity of the model run is key to watch for.
 - Continuity run to run.
 - Continuity with indices.

References:

- Branson, Anthony G. and Livezey, Robert E. 1987: Classification, Seasonal and Persistence of Low-Frequency Atmospheric Circulation Patterns. *Mon Wea Rev* **115**, 1083-1126
- Climate Prediction Center – Monitoring Weather and Climate at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/daily_mjo_index/mjo_index.html
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/all_index.html
- Climate Prediction Center – Northern Hemisphere Teleconnection Patterns at:
<http://www.cpc.ncep.noaa.gov/data/teledoc/telecontents.html>

- Madden, Roland, NCAR (Retired) Foresight Weather: NCAR COMET Program at: <http://meted.ucar.edu/climate/mjo/index.htm>
- Non-Operational Web Side of HUUG VAN DEN DOOL at the Climate Prediction Center, Center, National Centers for Environmental Prediction at: <http://www.cpc.ncep.noaa.gov/products/people/wd51hd/>
- Weickmann, Klaus and Berry, Edward 2005: A Synoptic-dynamic model of Subseasonal Atmospheric Variability (submitted for publication in Monthly Weather Review 10/05) or <http://www.cdc.noaa.gov/MJO/Predictions/wb2006.pdf>
- http://www.cdc.noaa.gov/people/klaus.weickmann/disc092804/Weather_Climate_Discussion_28SEP04.html

Additional Links:

SSEC-

<http://www.ssec.wisc.edu/data/geo/mtsats/> <http://www.ssec.wisc.edu/data/geo/met5/>

MJO Information-

http://www.cpc.ncep.noaa.gov/products/precip/CWlink/daily_mjo_index/mjo_index.shtml

<http://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/mjo.shtml>

<http://www.cpc.ncep.noaa.gov/products/precip/CWlink/>

http://www.cdc.noaa.gov/people/klaus.weickmann/disc021506/weather_climate_discussion_10Feb06.html

Teleconnection – Atmospheric monitoring indices-

http://www.cpc.ncep.noaa.gov/products/precip/CWlink/all_index.html

<http://www.cpc.ncep.noaa.gov/data/teledoc/telecontents.shtml>

Helpful MJO and Atmospheric State discussions-

Atmospheric Insights - <http://weatherclimatelink.blogspot.com>

Expert MJO Discussions

http://www.cdc.noaa.gov/MJO/Forecasts/climate_discussions.html (intermittent)